PRICE RIVER, SAN RAFAEL RIVER, AND MUDDY CREEK TMDLS FOR TOTAL DISSOLVED SOLIDS WEST COLORADO WATERSHED MANAGEMENT UNIT, UTAH

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Prepared for:

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LIST OF ACRONYMS

BLM	Bureau of Land Management
BMP	Best Management Practice
BOR	Bureau of Reclamation
CBM	coal-bed methane
cfs	cubic feet per second
DEQ	Utah Department of Environmental Quality
DO	Dissolved Oxygen
EWCD	Emery Water Conservancy District
Fe	Iron
gpm	gallons per minute
L	liter
LA	load allocation
M&I	municipal and industrial
mg	milligrams
MOS	margin of safety
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
PIP	Project Implementation Plan
POC	Parameter of Concern
SCS	Soil Conservation Service
SLA	sum of individual load allocations
SWLA	sum of individual wasteload allocations
TDS	total dissolved solids
TMDL	total maximum daily load
UAC	Utah Administrative Code
USFS	United States Forest Service
USGS	United States Geological Survey
WCRW	West Colorado River Watershed
WLA	wasteload allocation

1.0 INTRODUCTION

This TMDL study has been prepared for the Price River, San Rafael River, and Muddy Creek watersheds. These three watersheds encompass a large portion of the West Colorado Watershed Management Unit located in east-central Utah. Water quality assessments completed by the Utah Department of Environmental Quality, Division of Water Quality (DEQ) in 1997 resulted in several stream segments in these watersheds being listed on the Utah's 303 (d) list for impaired waters in 2000. The DEQ determined that primarily due to high concentrations of total dissolved solids (TDS) several portions and/or tributaries of the Price River its headwaters and the Green River are non-supporting or partially supporting of their agricultural use classifications. Additionally, for certain smaller river sections, pH, dissolved oxygen (DO), and dissolved iron (Fe) are also cited as causing impairment. The water quality assessment performed by the DEQ, which was also supported by water quality sampling performed by the Emery County Water Conservancy District (EWCD), also revealed that agricultural use classifications are not being supported in several stream segments in the San Rafael and Muddy Creek watersheds as a result of high concentrations of TDS in these waters. The impaired stream segments in the watershed are listed in Table 1-1.

Section 303 (d) of the Clean Water Act requires states to identify waterbodies not currently meeting water quality standards after technology-based controls are in place. Consequently, states are required to have TMDLs established in order to attain water quality standards for impaired waters. The TMDL establishes allowable loadings for pollutants for a given waterbody. Although pH, dissolved oxygen (DO), and iron (Fe) have also been cited as causing water quality impairments in the Price River and one tributary (see Table 1-1), the focus of this TMDL study is TDS. As described in Section 3.1 of this report, analyses of available data indicate that there are no impairments attributable to DO and pH (Toole 2003).

This section of the report describes the purposes of this TMDL study, the watersheds studied, and the associated water quality impairments. Section 2 of this report describes the applicable water quality standards and the establishment of target sites and a TMDL endpoint. Section 3 discusses the assessment of the current water quality in the watersheds and impairment analysis. Section 4 addresses the sources of TDS loading in the watersheds. Section 5 describes the methods that were used to establish TDS loading capacity, and Section 6 describes the TMDL allocations required to meet established TMDL endpoints.

Table 1-1 Impaired Stream Segments in the Price River, San Rafael, and Muddy Creek Watersheds due to TDS loadings[1]

Price River Watershed	San Rafael River Watershed	Muddy Creek Watershed
Non-supporting segments[2]:	***Non-supporting segments:***	***Non-supporting segments:***
Gordon Creek and tributaries from confluence with Price River to headwaters	Huntington Creek tributaries from the confluence with Cottonwood Creek to Utah highway 10	Muddy Creek and its tributaries from Quitchupah Creek confluence to the Utah Highway 10 bridge
Pinnacle Creek from confluence with Price River to headwaters[6]	Huntington Creek and tributaries from Highway 10 crossing to USFS boundary[7]	Quitchupah Creek from confluence with Ivie Creek to the Utah Highway 10 bridge
Price River and tributaries from confluence with Green River to near Woodside[3]	Cottonwood Creek from the confluence with Huntington Creek to Highway 57	Ivie Creek and its tributaries from the confluence with Muddy Creek to Utah Highway 10
Price River and tributaries from near Woodside to Soldier Creek confluence	Rock Canyon Creek from confluence with Cottonwood Creek to headwaters[5]	Muddy Creek from the confluence with Fremont River to Quitchupah Creek confluence
Lower Grassy Trail Creek from Grassy Trail Creek Reservoir to headwaters [4]	San Rafael River from Buckhorn Crossing to the confluence with Huntington Creek and Cottonwood Creek	
Partially-supporting segments[2]:	San Rafael River from the confluence with the Green River to Buckhorn Crossing	
Price River and its tributaries from Coal Creek to Carbon Canal Diversion		

Source: DEQ (2000)
1. All impairments are due to measured TDS concentrations and also dissolved oxygen and iron concentrations as noted.
2. Non-support is defined as TDS criteria that were exceeded at least two times and the criterion was exceeded in more than 25% of the samples. Partial support for TDS is defined as criterion that was exceeded at least two times and the criterion was exceeded in more than 10% but less than 25% of the samples.
3. Includes impairment for DO and Fe
4. This reach is listed in DEQ (2000) as impaired due to pH. More recent information indicates that it can be delisted.
5. Rock Canyon Creek is not listed as impaired in DEQ (2000) but the available data indicate that there is impairment from TDS.
6. Pinnacle Creek is not listed in DEQ (2000) but recent information indicates that there is impairment from TDS.
7. This reach is not listed in DEQ (2000), but is included in the draft Utah 2004 303(d) list of waters.

1.1 Watershed Characterization

The Price River, San Rafael River, and Muddy Creek watersheds, which collectively make up the West Colorado River Watershed (WCRW) TMDL, are located in east-central Utah, approximately 100 miles southeast of Salt Lake City (Map 1). The WCRW is generally encompassed within Carbon and Emery counties and is approximately 100 miles in length north to south and 65 miles in length east to west (Map 2). Elevations within the WCRW range from approximately 3,700 feet to 11,000 feet.

Insert Map 1

Insert Map 2

The Price River is the northernmost river in the WCRW. It is approximately 50 miles long and discharges into the Green River above Green River, Utah. The San Rafael River, located further south, is approximately 55 miles long and empties into the Green River below Green River, Utah. Muddy Creek, the southernmost river in the WCRW, is approximately 40 miles long and empties into the Dirty Devil River. The Green and Dirty Devil Rivers ultimately empty into the Colorado River. Smaller hierarchy streams in the WCRW include Gordon Creek in the Price River watershed; Huntington Creek, Cottonwood Creek, Rock Canyon Creek, and Ferron Creek in the San Rafael River watershed; and Quitchupah Creek and Ivie Creek in the Muddy Creek watershed. The WCRW contains approximately 2,550 perennial stream miles. Of this total, approximately 1,986 stream miles were assessed for beneficial use by the DEQ (DEQ 2000).

1.1.1 Land Use and Administration

Current land uses in the WCRW are agriculture (crop production and rangeland), mixed use public lands, and gas and coal production. There is a small amount of forest production in the higher elevations of the WCRW.

Based on data from the USGS (2000), existing land uses in the WCRW were grouped into seven general land use categories. Current land use distributions for the three watersheds in the WCRW are given in Table 1-2.

Table 1-2 Land Use Distributions in the WCRW

Land Use	Price River watershed		San Rafael River watershed		Muddy Creek watershed	
	Area (acres)	% of total area	Area (acres)	% of total area	Area (acres)	% of total area
Barren	91,737	7.0%	328,767	12%	225,932	13%
Residential	3,812	<1%	2,877	<1%	1,105	<1%
Agriculture	16,341	<1%	20,202	1%	4,618	<1%
Rangeland	792,271	66%	1,022,531	73%	662,453	75%
Forest	300,125	24%	179,300	13%	97,309	11%
Water	1,954	<1%	1,982	<1%	173	<1%
Wetland	228	<1%	304	<1%	192	<1%
TOTAL	1,206,468	100.0%	1,555,963	100%	991,782	100%

Source: USGS 2000

Approximately 73 percent of the land in the WCRW is administered by three federal agencies: the U.S. Forest Service (USFS), the Bureau of Land Management (BLM), and the National Park Service (NPS).

The State of Utah administers about 11 percent of the WCRW, while 16 percent is privately owned land. Land administration types and acreages for the three watersheds are listed in Table 1-3. Maps 3, 4, and 5 show the land administrative ownership for the three sub-watersheds in the WCRW.

Table 1-3 WCRW Land Ownership/Administration

Land Ownership/ Administrator	Price watershed		San Rafael watershed		Muddy Creek watershed	
	Area (acres)	% of area	Area (acres)	% of area	Area (acres)	% of area
USFS	86,656	7%	335,920	21%	196,980	20%
BLM	532,559	44%	915,885	59%	644,929	65%
State of Utah	143,131	12%	160,256	10%	85,399	8%
Private	424,861	35%	138,847	9%	46,313	5%
Nat Parks/Mon.	0	0%	45	<1%	17,571	2%
State Parks/Rec. Areas	0	0%	393	<1%	0	0%
State Wildlife Areas	15,604	1%	1,171	<1%	0	0%
Water	3,133	<1%	2,778	<1%	91	<1%
TOTAL	1,205,944	100%	1,555,295	100%	991,283	100%

Source: DEQ 2000

1.1.2 Geology

1.1.2.1 Physiography and Topography

The WCRW is located in the northwestern portion of the Colorado Plateau physiographic province, within the Mancos Shale Lowlands (Stokes 1986). The Mancos Shale Lowlands is characterized by sloping, gravel-covered pediments, rugged badlands and narrow, flat-bottomed alluvial valleys (Stokes 1986). The Mancos Shale Lowlands is bounded by the Book Cliffs-Roan Plateau to the north, the San Rafael Swell to the southeast, and the Wasatch Plateau to the west. The Book Cliffs-Roan Plateau is a series of erosional cliffs, including the Book Cliffs, Roan Cliffs and Badland Cliffs that separate the Mancos Shale Lowlands from the Uinta Basin to the northeast. The San Rafael Swell, an anticline structure of uplifted and exposed Paleozoic and Cretaceous rocks (Stokes 1986), is approximately 80 miles long and 30 miles wide. The Wasatch Plateau is primarily sedimentary rock that contains zones of normal faulting, which forms long, narrow horst and graben structures. The Joes Valley Fault system is found along the eastern edge of the Wasatch Plateau and separates it from the Mancos Shale Lowlands.

Insert Map 3

Insert Map 4

Insert Map 5

1.1.2.1 Stratigraphy and Structure

Stratigraphic units in the WCRW include exposed igneous and sedimentary units that range from Triassic to Tertiary in age (Map 6). The exposed rocks include limestone, sandstone, shale, conglomerate, coal, and various types of igneous rocks. Units of the Mesaverde Group form the distinct cliffs along the northern and western edge of the WCRW. Within the Mesaverde Group is the coal-bearing Blackhawk Formation. The Mancos Shale Formation is exposed in the middle reaches of the WCRW. Within the Mancos Shale, the Ferron Sandstone Member is a source of coal and groundwater. Surrounding the San Rafael Swell are the Dakota Sandstone, Morrison Formation, Entrada Sandstone, Navajo Sandstone, and Chinle Shale units.

Insert Map 6

1.1.2.2 Mancos Shale and Blackhawk Formation

Due to their geochemical composition, range of exposure in the WCRW, and erodability from physical contact with water, the Mancos Shale and Blackhawk Formations present natural sources of soluble salts. Both are similar in composition in that they contain coal-bearing beds, formed in coastal-marine environments, and are predominately shale units. Through mineral dissolution and cation/anion exchange, shale and coal beds are a known contributor of increased TDS in surface water and groundwater (Freeze and Cherry 1979).

The Mancos Shale Formation is a known source of soluble sodium-sulfate minerals such as mirabilite ($Na_2SO_4 * 10H_2O$) and thenardite (Na_2SO_4) (Waddell et al. 1979). Thickness of the Mancos Shale ranges from 2,300 to 6,100 feet. It consists of six members, the Upper Blue Gate, Emery Sandstone, Blue Gate, Garley Canyon Sandstone, Ferron Sandstone, and Tununk Shale, that were deposited from the transgression and regression of coastal marine environments (BLM 2000, Frazier and Schwimmer 1987). The Upper Blue Gate Member is a light to dark-gray shale and shaley siltstone with minor thin sandstone beds. The Emery Sandstone consists of two fine-grained, light brown quartzose sandstones with an average thickness of 285 feet. A gray, thin-bedded shale averaging 35 to 50 feet thick separates the two sandstones units. The Blue Gate Member consists of light bluish gray thin-bedded shale and shaley siltstones that range in thickness from 1,600 to more than 3,500 feet (BLM 1999). The Garley Canyon Sandstone consists of two thin, cliff forming sandstone beds, separated by shale, which ranges in thickness from 70 to 220 feet (BLM 1999). The Ferron Sandstone consists of alternating fluvial-deltaic sandstones and thick coals, which range in thickness from 250 to 490 feet (BLM 2000). Deposition of the Ferron Sandstone occurred by a repeating series of wave and river dominated shorelines, delta plains, and bog swamp facies (BLM 1994). The Tununk Shale consists of light- to dark-gray, thin-bedded shale and shaley siltstones that range in thickness from 400 to 650 feet (BLM 2000).

The Blackhawk Formation of the Mesaverde Group is an important large coal-bearing formation. It consists of bedded quartzose sandstones with shaley siltstone, shale, carbonaceous shale, and coal beds that intertongue with and pinch-out into the Mancos Shale (BLM 1997, Hettinger and Kirschbaum 2002). Thickness of the Blackhawk Formation ranges from 700 feet to approximately 1,250 feet (BLM 1999, Hettinger and Kirschbaum 2002). Maps 7, 8, and 9 show the geologic formations for the three watersheds in the WCRW.

Insert Map 7

Insert Map 8

Insert Map 9

1.1.3 Soils

Information regarding soils data was taken from the Natural Resource Conservation Service (NRCS 2003). Soil series that dominate the WCRW are Casmos, Hanksville, Moenkopie, Nakai, Sheppard, and Strych. These soils can be characterized by the parent material and the climatic zones in which they were formed.

Higher elevations in the WCRW (8,000 to 11,000 feet), where the average annual precipitation ranges from 22-40 inches per year, have developed deeper soil profiles than lower elevation areas, where the average annual precipitation ranges from 6-8 inches per year. The loamy soils in the higher elevations are generally well drained, exhibit moderately rapid permeability, and relatively high organic matter content. Although slopes range from 20 to 70 percent in the upper regions of the WCRW, the high percentage of vegetative cover in these areas holds the soil in place. High elevation soils were derived mainly from igneous material and are thus low in soluble salts. Therefore, these soils provide little TDS loading into stream segments in the WCRW. Land use in the higher elevations of the WCRW is centered on forestry and livestock grazing. These soils are predominantly represented by Bundo, Castino, Midfork, Skylick, and Trag soil series.

The middle portions of the WCRW are dominated by soils that were derived predominately from marine shale deposits. Slopes in the area range from 0 to 10 percent, and the mean annual precipitation is approximately 7 inches. The shale derived soils, along with the underlying shale deposits in these areas, are a significant source of TDS loading in WCRW streams. Water moving within the soil profile can dissolve salts and convey them to the streams in surface runoff and via groundwater. Groundwater in contact with the underlying shale formations provides an additional source of TDS loading in WCRW streams.

Soils in the middle portion of the WCRW, where most of the irrigated agricultural land is located, are dominated by two distinctly different soil textural types: silty clay loams and sandy clay loams. The silty clay loam soils are represented by the Billings, Chipeta, Penoyer, Ravola, Saltair and Killpack soil series. These soils are fine textured, exhibit slow permeability and moderate to rapid runoff, and are thus susceptible to erosion caused by irrigation and intense thunderstorms. The soluble salt content of these soils ranges from 0.08 to 2.1 percent and is due to the shaly parent material from which they were derived. The sandy clay loams are represented by the Sanpete and Sanpete-Minchey soil series. These soils contain a significant amount of sand, exhibit moderate to rapid permeability and slow runoff, and have soluble salt contents ranging from 0.02 to 0.7 percent.

Lower portions of the WCRW are dominated by soils that are derived primarily from sedimentary and igneous rocks. The soils derived from sedimentary material are generally calcareous in nature and are therefore also a potential source of TDS loading in the lower portions of the WCRW. Slopes in the lower region range from 0 to 60 percent. Permeability and runoff from these soils is moderate. Land use in this portion of the WCRW is associated with livestock grazing.

1.1.4 Vegetation

The amount of precipitation, along with slope aspect, generally determines the type of vegetation found in the WCRW. Vegetation cover ranges from spruce, fir, and aspen at higher elevations, where precipitation averages nearly 30 inches per year, to cheatgrass, ricegrass, blackbrush, greasewood, and atriplex at lower elevations, where the average annual precipitation is about 7 inches per year. Mid-elevation areas, where the annual precipitation averages from 10-15 inches per year, are dominated by juniper, sagebrush, rabbitbrush, and ricegrass.

The distribution and occurrence of some of the lower elevation species, notably greasewood and atriplex, is somewhat controlled by the concentration of salt in the soil. These species can withstand salt concentrations in excess of 10,000 parts per million (Skougard and Brotherson 1979), well above the threshold for non-salt tolerant species.

1.1.5 Climate

The average annual precipitation at lower elevations in the WCRW ranges from over 9 inches at Price to less than 8 inches at Emery. Lower elevations of the WCRW receive most of the yearly total precipitation in the spring and summer months. Summer precipitation is generally from localized, intense thunderstorms that may cause erosion due to increased runoff. Higher elevations in the Wasatch Plateau receive in excess of 30 inches per year, 70 percent of which falls in the October-April time period (USGS 1986a). Winter precipitation in the WCRW usually is in the form of snow. The accumulation of snow, especially in the higher elevations, provides support for plant communities at the base of the mountains as well as along river courses. Runoff from snowmelt is used for irrigation purposes, municipal use, and by industry.

Average daily temperatures in the WCRW range from approximately 8 to 90 degrees Fahrenheit (Western Regional Climate Center 2003). Temperature and precipitation data for Price, Ferron, and Emery are summarized in Tables 1-4, 1-5, and 1-6 and Figures 1-1, 1-2, and 1-2, respectively.

Table 1-4 Price Temperature and Precipitation Data (1968-2000)

Month	Maximum ^{0}F	Minimum ^{0}F	Mean ^{0}F	Maximum (in./month)	Minimum (in./month)	Mean (in./month)
January	36.9	13.4	25.1	2.57	0	0.8
February	42.8	19.7	31.2	3.81	0	0.76
March	52.5	27.6	40.1	2.38	0	0.74
April	63.2	34.6	48.9	2.01	0	0.53
May	72.5	42.9	57.7	2.34	0	0.73
June	83.8	52.1	68.1	2.41	0	0.61
July	90	58.3	74.2	3.14	0.01	0.9
August	88.4	57	72.7	4.21	0.02	1.07
September	79.5	48.1	63.9	3.12	0	1.1
October	64.8	37.5	51	4.34	0	1.32
November	49.5	25.7	37.3	3.47	0	0.6
December	40.1	16.7	28.4	1.51	0	0.48
ANNUAL	63.7	36.1	49.9	17.46	5.83	9.65

(Data source: Western Regional Climate Center` 2003.)

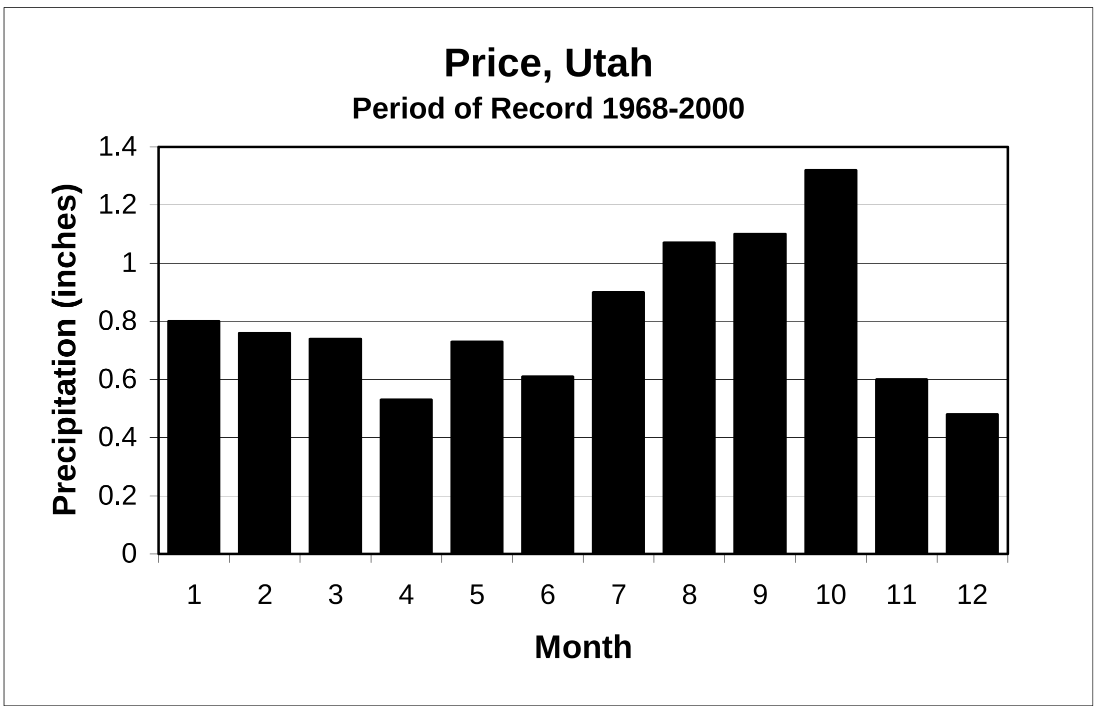

Figure 1-1 Mean monthly precipitation at Price, Utah, 1968-2000

Table 1-5 Ferron Temperature and Precipitation Data (1948-2000)

Month	Maximum ^{0}F	Minimum ^{0}F	Mean ^{0}F	Maximum (in./mo)	Minimum (in./mo)	Mean (in./mo)
January	35.8	11.1	23.5	2.65	0	0.67
February	41.7	17.2	29.4	2.41	0	0.59
March	51	25.3	38.2	1.88	0	0.61
April	60.7	33.3	47	2.3	0	0.5
May	70.6	42.4	56.5	2.24	0.03	0.74
June	80.7	51.1	65.9	1.95	0	0.5
July	87.3	57.8	72.5	3.47	0.01	0.89
August	84.9	55.4	70.2	3.14	0.01	1.12
September	77.3	46.7	62	4.36	0	0.96
October	65.6	35.3	50.4	2.64	0	0.84
November	49.6	22.9	36.3	2.73	0	0.55
December	38.4	14	26.2	1.71	0	0.5
ANNUAL	62	34.4	48.2	13.82	5.03	8.47

(Data source: Western Regional Climate Center 2003.)

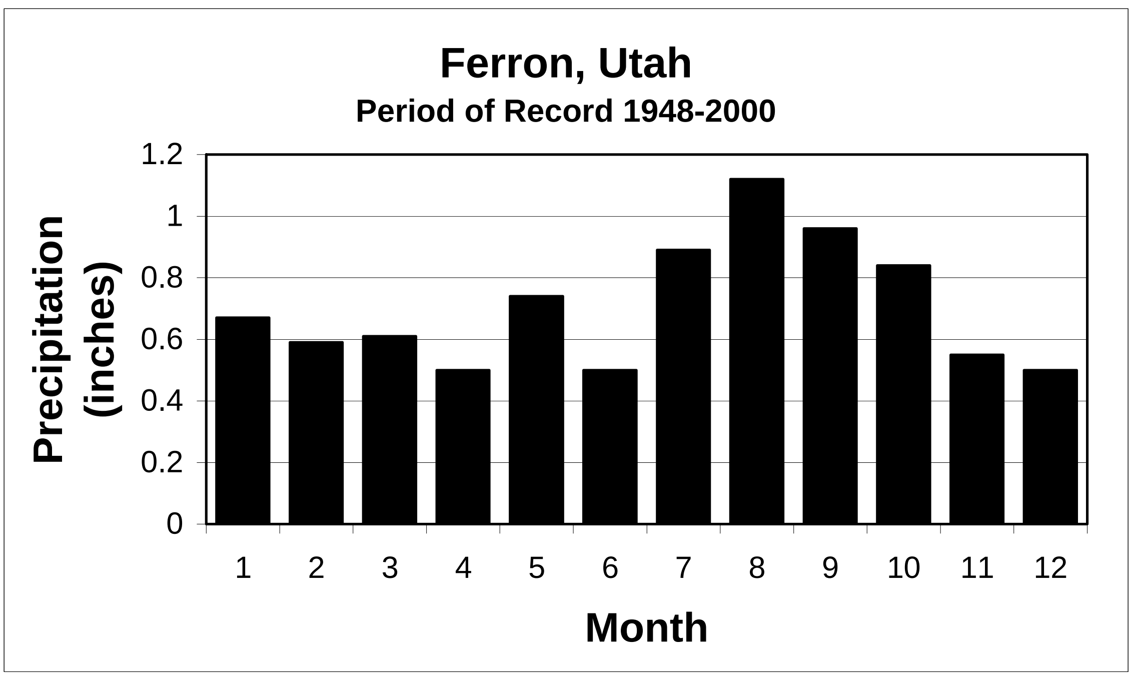

Figure 1-2 Mean Monthly Precipitation at Ferron, Utah, 1948-2000

Table 1-6 Emery Temperature and Precipitation Data (1901-1978)

Month	Maximum ^{0}F	Minimum ^{0}F	Mean ^{0}F	Maximum (in./month)	Minimum (in./month)	Mean (in./month)
January	36.7	10.9	23.9	2.5	0	0.47
February	42	16.1	29.1	3.01	0	0.5
March	49.7	22.8	36.2	1.97	0	0.43
April	59.3	30	44.6	2.6	0	0.39
May	68.8	37.8	53.3	4	0	0.6
June	77.6	45.4	61.5	3.34	0	0.51
July	83.2	52.2	67.7	4.26	0	0.83
August	81.3	50.7	66	5.47	0	1.12
September	74.4	42	58.2	3.48	0	0.9
October	63.3	32.3	47.8	3.87	0	0.81
November	49.7	21.6	35.7	2	0	0.33
December	39.3	13.5	26.4	1.7	0	0.44
ANNUAL	60.4	31.3	45.9	16.84	0.94	7.33

(Data source: Western Regional Climate Center 2003.)

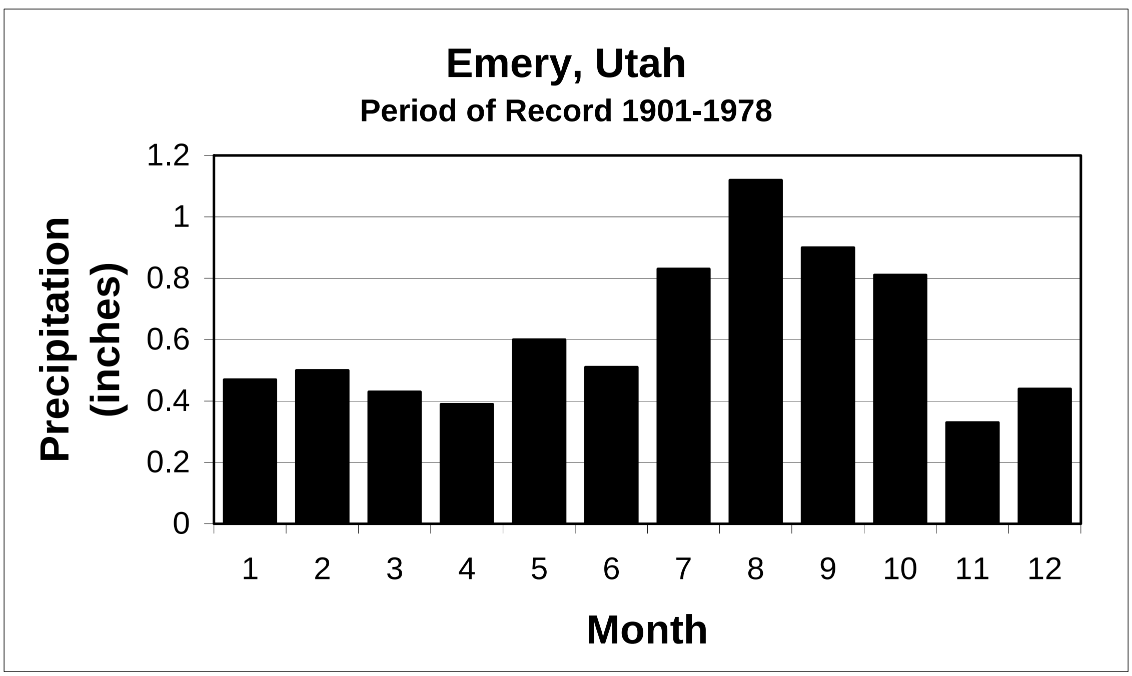

Figure 1-3 Mean monthly precipitation at Emery, Utah, 1901-1978

2.0 UTAH WATER QUALITY STANDARDS AND TMDL TARGET SITES/ENDPOINTS

The purpose of a TMDL is to attain and maintain applicable water quality standards. The TMDL specifies the maximum amount of a pollutant that a body of water can receive in order to meet these goals.

In order to evaluate the attainment of acceptable water quality, measurable in-stream endpoints must be established. These endpoints may be narrative or numeric criteria, and represent the water quality goals that are to be met by load reductions specified in the TMDL. The criteria for this TMDL are based on Utah state water quality standards (UAC 2003). Target sites represent those locations along the streams in the WCRW where constituent loads are calculated and allocated to upgradient sources contributing load to the target site. In this TMDL, target sites were selected downgradient of the three distinguishable land uses in each of the watersheds: 1) upper forest lands, 2) middle agricultural and urban uses, and 3) BLM rangeland. The target sites were selected at locations where there was sufficient chemical and flow data to allow for the calculation of constituent loads.

2.1 Water Quality Standards

Water quality standards applicable to streams within the WCRW are comprised of designated uses and numerical criteria. Narrative standards, as well as the State of Utah's antidegradation policy, also apply. Additionally, streams in the WCRW are protected by requirements of *Proposed Water Quality Standards for Salinity including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System* (June 1975) and subsequent supplements and revisions.

2.1.1 Use Designations

The DEQ has classified the waters in the State of Utah so as to protect the beneficial uses designated within each stream reach. These classifications and associated beneficial uses are presented in Table 2.1. The beneficial use classification assigned to the Price River, San Rafael River, Muddy Creek, and their tributaries are presented in Table 2-2.

Table 2-1 Utah Water Quality Classifications/Beneficial Uses

Class 1	Protected for uses as a raw water source for domestic water systems Class 1A: Reserved Class 1B: Reserved Class 1C: Protected for domestic purposes with prior treatment by treatment processes as required by the Utah Division of Drinking Water
Class 2	Recreational and aesthetic use Class 2A: Protected for primary contact recreation such as swimming Class 2B: Protected for secondary contact recreation such as boating, wading or similar uses
Class 3	Protected for use by aquatic wildlife Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain Class 3B: Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain Class 3C: Protected for non-game fish and other aquatic life, including necessary aquatic organisms in their food chain Class 3D: Protected for waterfowl, shore birds, and other water-oriented wildlife not included in Classes 3A, 3B or 3C, including the necessary aquatic organisms in their food chain Class 3E: Severely habitat-limited waters
Class 4	Protected for agricultural uses including irrigation of crops and stock watering
Class 5	The Great Salt Lake. Protected for primary and secondary contact recreation, aquatic wildlife, and mineral extraction

Source: Utah Administrative Code (UAC) R317-2-6

Table 2-2 Use Classifications Assigned to Stream Segments in the WCRW

Stream Segment	Use Classifications
Gordon Creek and tributaries from confluence with Price River to headwaters	1C, 2B, 3A, 4
Grassy Trail Creek and tributaries from Grassy Trail Creek reservoir to headwaters	1C, 2B, 3A, 4
Price River and tributaries from confluence with Green River to near Woodside	2B, 3C, 4
Price River and tributaries from near Woodside to headwaters	1C, 2B, 3A, 4
Portion of Lower Grassy Trail Creek	2B, 3C, 4
Huntington Creek and tributaries from Utah Highway 10 to headwaters	1C, 2B, 3A, 4
Huntington Creek and tributaries from the confluence with Cottonwood Creek to Utah highway 10	2B, 3C, 4
Cottonwood Creek from the confluence with Huntington Creek to highway 57	2B, 3C, 4
San Rafael River from Buckhorn Crossing to the confluence with Huntington Creek and Cottonwood Creek	2B, 3C, 4
San Rafael River from the confluence with the Green River to Buckhorn Crossing	2B, 3C, 4
Muddy Creek and its tributaries from Quitchupah Creek confluence to the Utah highway 10 bridge	2B, 3C, 4
Muddy Creek from the confluence with Fremont River to Quitchupah Creek confluence	2B, 3C, 4
Quitchupah Creek from confluence with Ivie Creek to the Utah highway 10 bridge	2B, 3C, 4
Ivie Creek and its tributaries from the confluence with Muddy Creek to Utah highway 10	2B, 3C, 4

Source: Utah Administrative Code (UAC) R317-2-13.1

2.1.2 Numeric Criteria

Numeric criteria, set forth in Utah Administrative Code (UAC) R317-2-14, have been promulgated for each of the beneficial use classes assigned to waters in the State. Of the use classifications assigned to the streams in the WCRW, numeric criteria for TDS only apply for agricultural use (beneficial use class 4). The numeric criterion for TDS in the WCRW streams is 1,200 mg/L. Although this numeric criterion has been established, Section R317-2-14 of the UAC provides that TDS limits may be adjusted if the adjustment does not impair the beneficial use of the receiving water.

2.1.3 Narrative Standards

In addition to numeric criteria, narrative standards set forth at UAC R317-2-7.2 also apply to the WCRW streams. These narrative standards generally address the discharge or placement of wastes or other substances in a waterbody that are offensive, that will cause conditions that produce undesirable aquatic life or tastes in edible aquatic organisms, that result in undesirable physiological responses in aquatic life, or that produce undesirable human health effects.

2.1.4 Antidegradation Policy

The State's antidegradation policy is set forth at UAC R317-2-3. If a water body has a better water quality than necessary to support its designated uses, the antidegradation policy requirements dictate that the existing water quality shall be maintained and protected, unless the State finds that a lowering of water quality is necessary to accommodate important economic or social development in the area in which the water is located. The antidegradation policy applies to three categories of high quality waters designated by the State.

Waters in the State designated as High Quality Waters – Category 1 are listed at UAC R317-2-12.1. As set forth in UAC R317-2-12.1.1, these include all surface waters geographically located within the outer boundaries of the U.S. National Forests, whether on public or private lands, with limited exceptions. Portions of Gordon Creek, Huntington Creek, Cottonwood Creek, Muddy Creek, and Quitchupah Creek are located within the outer boundary of the Manti-La Sal National Forest and are, therefore, designated Category 1, High Quality Waters.

2.1.5 Colorado River Salinity Standards

Due to the concern of the adverse impacts of high salinity concentrations on water use, the Colorado River Basin states established the Colorado River Basin Salinity Control Forum in 1973 to address the issue of salinity in the Colorado River System. The Forum submitted to the EPA in June 1975 a report entitled *Proposed Water Quality Standards for Salinity Including Numeric Criteria and Plan of Implementation for Salinity Control-Colorado River System*. A supplement was issued on August 26, 1975, entitled *Supplement, Including Modifications to Proposed Water Quality Standards for Salinity Including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System, June 1975*. These standards require the development of a plan that would maintain the flow-weighted average annual salinity at or below 1972 levels. As set forth at UAC R317-2-4, waters of the Colorado River and its tributaries shall also be protected by these requirements.

2.2 TMDL Endpoint and Target Sites

This TMDL establishes an endpoint and target sites where loading capacities for TDS are calculated and allocated to upgradient sources contributing TDS load to a target site. The initial endpoint selected for this TMDL for TDS is the water quality criterion of 1,200 mg/L. This endpoint may be modified at selected target sites to reflect an adjustment in the TDS criterion based on specific site conditions as allowed for under the Utah water quality standards. The basis for selection of site-specific criteria for TDS is discussed in the Project Implementation Plan, which is Appendix A of this report.

The Price River, San Rafael River, and Muddy Creek watersheds can be divided into upper, middle, and lower reaches, based generally on land uses within the watersheds. As discussed in Section 3 of this report, water quality in the upper reaches of the watersheds meets TDS water quality standards. Land in this portion of the watershed is primarily forest lands managed by the BLM or USFS. TDS loading sources (e.g., Mancos Shale) and activities contributing TDS loading to streams in the watersheds (e.g., irrigation) predominantly occur in the middle sections of the watersheds, and it is within and below these areas where impairment in water quality is first noted. Much of the land in this section of the watershed is privately owned, and is where the majority of the irrigated land and urban areas are located. Impairment of water quality is also present in the lower reaches of the watershed. This portion of the watershed is primarily BLM administered land. Target sites in each watershed were located based on these watershed characteristics, as well as other considerations. These other considerations included bracketing sources within defined sub-watersheds and the amount and availability of water quality and flow data taken at and around the target site locations that allowed for the adequate assessment of water quality in the stream reaches above the target sites.

Two target sites were selected for establishing a TMDL in the Price River watershed, five target sites were selected in the San Rafael River watershed, and two target sites were selected for the Muddy Creek watershed. The selected target sites are shown on Map 2.

3.0 WATER QUALITY ASSESSMENTS AND IMPAIRMENT ANALYSIS

Surface water quality and flow data for all three watersheds within the WCRW were available from a number of sources, including the U.S. Environmental Protection Agency (USEPA) STORET data retrieval system (including data collected by the DEQ), the U.S. Geological Survey (USGS), and the Emery Water Conservancy District (EWCD). Together with other available information, such as watershed characteristics, and permitted discharge monitoring reports, these available data were compiled and reviewed to evaluate water quality impairment and to identify and characterize the significant causes and sources of TDS loading to surface waters in the WCRW.

3.1 Non-TDS Impairments

While the majority of impaired sections within the WCRW are listed due to TDS, there are also reported impairments due to pH, iron, and dissolved oxygen (DEQ 2000). Only one stream segment, Lower Grassy Creek Trail (Table 1-1) is listed as impaired due to pH. This segment is only 1.74 miles in length (DEQ 2000). The review of the STORET data for this segment over the period of 1997 to 2002 indicated that there are no exceedances (N=11) of the pH criterion (range of 6.5-9.0) for lab-analyzed pH samples. There is a single exceedance (pH=10; June 1998) for a field-measured pH value, although the corresponding lab analyzed pH for that date of 8.53 is within the standard range. Based on the data evaluation, this segment of Grassy Creek should not be listed as pH impaired.

The segment of the Price River between Utah DEQ STORET Stations 493165 (Price River at Woodside) and 493161 (Price River confluence with Green River) is listed as non-supporting for Class 3C waters in the West Colorado Watershed Unit, Water Quality Assessment Report (DEQ 2000). As noted in the Utah DEQ assessment report, this segment of the Price River is listed as non-supporting due to low dissolved oxygen (DO) and excess dissolved iron. The chronic criterion of Class 3C surface waters for dissolved oxygen is a minimum of 5.0 mg/L (30 day average) and a dissolved iron concentration of 1.0 mg/L.

This segment of the Price River is located between the San Rafael Swell to the south and the Uinta Uplift province to the north. Bedrock in this area includes those of the Mancos Shale and Mesa Verde Group. The Mancos Shale is mainly comprised of marine mudstones and siltstones with interbedded sandstone members that have been found to contain high amounts of soluble salts (Halite, Gypsum) in the shale and sandstones. The Mesa Verde Group includes sandstones with interbedded shale and coal seams. Sandstone formations within the study area have been found to contain iron-containing minerals as part of their mineralogy.

DO and iron measurements from Utah DWQ STORET Stations 493165 and 493161 were used for the assessment report (DEQ 2000) and for this study. In order to account for natural sources of dissolved iron, stations 493281, 493239, and 493253 that are located upstream of 493165 and 493161, and within the Mancos Shale and Mesa Verde Group formations, were also examined. A summary of the data is provided below in Table 3-1.

Table 3-1 Segments Listed for Iron and Dissolved Oxygen

STORET Station	Name	Period of Record	Number of Samples		Range		Mean		Number of Exceedances		Percent Exceedance	
			Fe (mg/L)	DO (mg/L)	Fe (mg/L)	DO (mg/L)	Fe (mg/L)	DO (mg/L)	Fe (mg/L)	DO (mg/L)	Fe (mg/L)[1]	DO (mg/L)[2]
493165	Price River at Woodside	1976 - 2002	47	258	0.01-1.48	3.86-14.45	0.13	8.91	3 [3]	1 [4]	6%	0.4%
493161	Price River at mouth	1980 - 2002	19	12	0.01-4.49	4.3-10.6	0.56	7.43	3 [5]	2 [6]	16%	17%
493239	Price River above Price WWTP	1975 - 2002	15	155	0.01-0.34	3.8-15.5	0.05	9.38	0	1 [7]	0%	1%
493253	Gordon Creek above Price River	1979 - 2002	9	30	0.01-6.81	1.5-16.9	0.78	8.66	1 [8]	2 [9]	11%	7%
493281	Price River above Price River Coal	1976 - 2002	48	207	0.01-6.1	4.0-15.3	0.15	9.43	1 [10]	1 [11]	2%	0.5%

Notes: 1. Utah DEQ Dissolved Iron Water Quality Criterion of 1.0 mg/L (Class 3C).
2. Utah DEQ Minimum Acute Dissolved Oxygen Water Quality Criterion of 5.0 mg/L (Class 3C)
3. 2/16/1995 (1.2 mg/L),8/8/1995 (1.2 mg/L), 2/3/2000 (1.48 mg/L).
4. 7/30/1998 (3.86 mg/L).
5. 10/21/1997 (4.49 mg./L), 5/25/1998 (1.65 mg/L), 8/19/2001 (2.87mg/L).
6. 6/23/1998 (4.3 mg/L), 10/21/1997 (4.7 mg/L).
7. 10/7/1993 (3.8 mg/L).
8. 7/30/1999 (6.81 mg/L).
9. 7/30/1999 (1.5 mg/L), 9/17/2002 (3.76 mg/L).
10. 2/14/1995 (6.1 mg/L)
11. 9/13/1977 (4.0 mg/L)

Dissolved oxygen measurements from the Lower Price River are summarized in Table 3-1 for the range and mean of measurements for the period of record shown. As shown in Table 3-1, there are some limited exceedances of the 5.0 mg/L DO minimum set by the Utah DEQ (Table 3-1). However, there have not been any exceedances of the DO standard at these locations within the last three years, which indicates that there are no current impairments based on DO. Based on discussions with Tom Toole of the Utah Department of Water Quality, these segments will be removed as impaired in the next 305(b) listing.

Dissolved iron measurements from the Lower Price River are summarized in Table 3-1 for the minimum, maximum, and the mean for the period of record shown. For stations 493165 and 493161, the iron water quality standard was exceeded three times during the noted period of sampling. This is equivalent to exceeding the standard 6 percent and 16 percent of the time. In general, dissolved iron concentrations increase from station 493165 downstream to station 493161 at the Price River confluence with the Green River. Seasonal variations in dissolved iron concentration and natural sources could not be examined in this study due to the sporadic and limited data available.

Sources of natural dissolved iron include transport by surface run-off and physical contact of the Price River with the Mancos Shale and formations within the Mesa Verde Group. Precipitation data is reported as monthly totals; therefore daily run-off associated with daily measurements of iron exceedances could not be determined. The Mancos Shale and Mesa Verde Group is encountered in the upper and lower reaches of the Price River. Dissolution of iron-bearing minerals from these formations where the Price River is in contact with the Mancos Shale and Mesa Verde Group is a possible contributor to elevated dissolved iron in the Price River. Since stations 493281, 493253, and 493239 are also located within the Mancos Shale and Mesa Verde Group, they were analyzed for exceedances of the iron water quality criteria. As shown in Table 3-1, iron exceeds the water quality standard once at stations 493281 (6.1 mg/L) and 493253 (6.81 mg/L). Based on the low occurrence of exceedances and lack of identified sources of iron, all of the reaches listed for dissolved iron have been delisted in the draft Utah 2004 303 (d) list of waters.

3.2 TDS Impairments- DEQ and EWCD Water Quality and Flow Data

TDS concentrations and flow data were collected by the DEQ at several monitoring sites within each of the three watersheds in the WCRW. These data were queried through the USEPA's STORET data retrieval system. The data collected at the 26 stations located within the WCRW were not consistent over the period of record. At times water chemistry and flow data were collected; other times only water chemistry or only flow data was collected. The EWCD has collected water chemistry and flow data for the San Rafael River and Muddy Creek watersheds from 1987 to the present. The EWCD consistently collected data at each of eleven monitoring stations during either the second or third week of each month. Data was also collected at eight additional monitoring stations, but only during 2001. Data from the DEQ and EWCD monitoring locations in the Price River, San Rafael River, and Muddy Creek watersheds are shown in Figures 3-1, 3-2, and 3-3, respectively. Monitoring station descriptions and period of record for data at each location are shown in Table 3-2.

In addition to the available data, there are several other studies that are planned or currently being conducted that may result in data that can be utilized to update the TMDL in the future. These studies include intensive sampling being conducted by the Utah DEQ in 2003, a three-year study on transit sources of TDS loading in the San Rafael River that is being lead by the BLM, and a water balance salinity study being conducted by Utah State University.

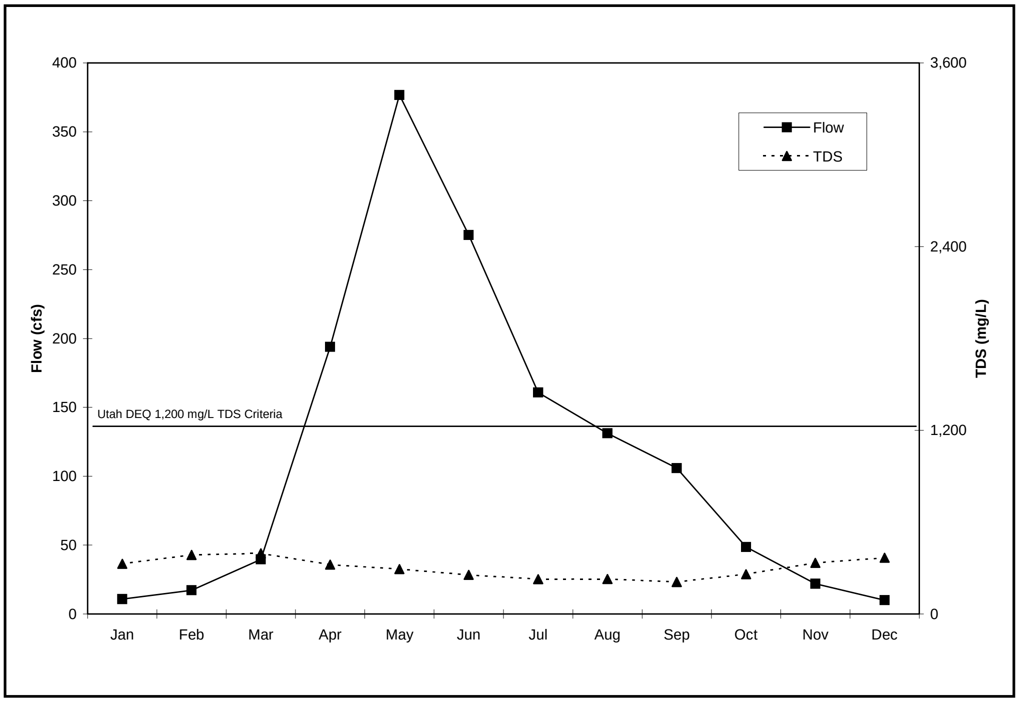

Figure 3-1 **Average Monthly Flow and TDS at STORET 493281 (Price River above Price River Coal)**

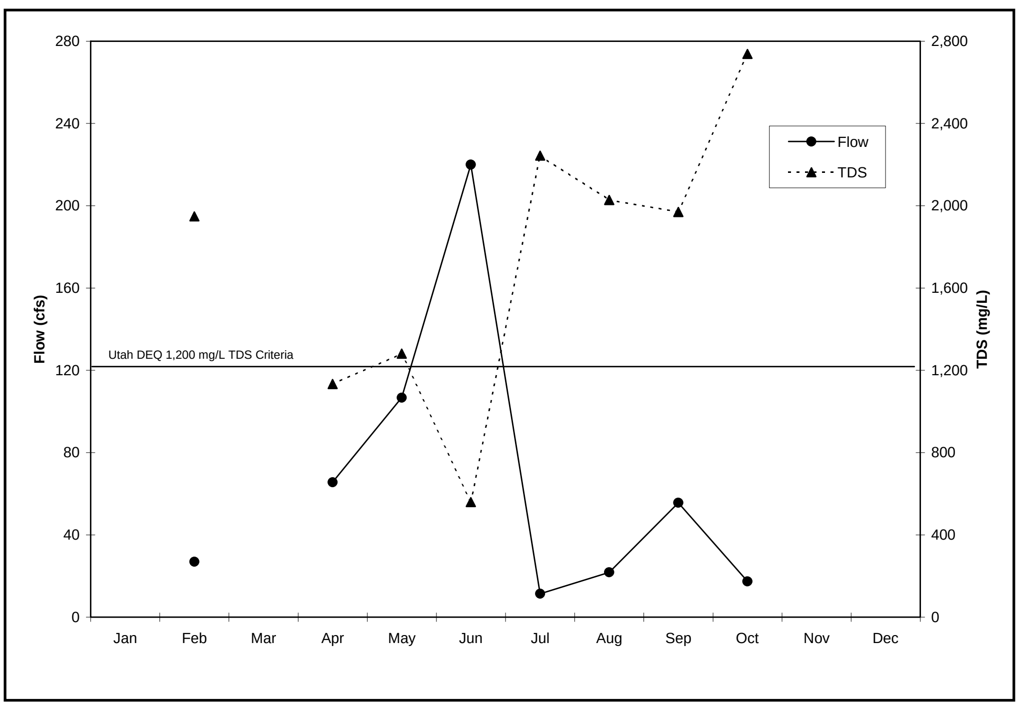

Figure 3-2 **Average Monthly Flow and TDS at STORET 493239 (Price River above Price WWTP at Wellington Bridge)**

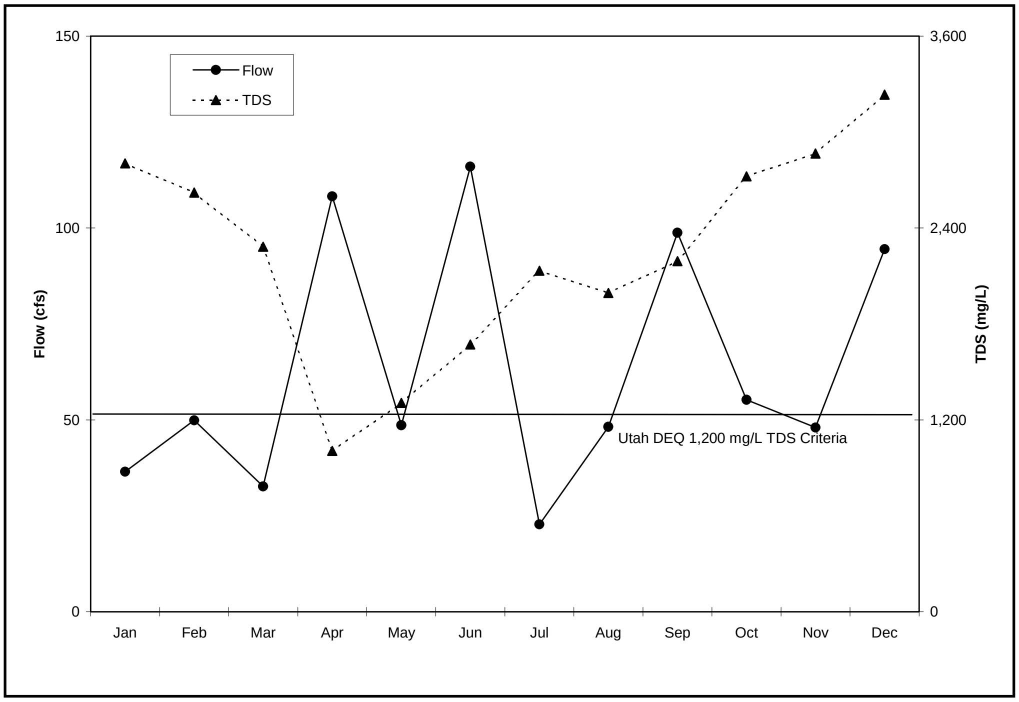

Figure 3-3 Average Monthly Flow and TDS at STORET 493165 (Price River near Woodside at US 6 crossing)

Table 3-2 DEQ and EWCD Monitoring Station Descriptions (shown on Maps 10, 11, and 12)

Station ID	Station Name	Start	End	SamplingEvents
STORET #[1]				
493029	San Rafael R. at US 24 crossing	2/22/90	12/12/01	60
493034	San Rafael R. at Buckhorn Rd. crossing	6/12/92	6/10/98	11
493052	Huntington Cr. above Huntington lagoons outfall	4/17/90	6/10/98	30
493053	Huntington Cr. above Utah Power and Light	7/29/97	11/20/02	15
493080	Ferron Cr. below Ferron lagoons	8/03/90	10/17/02	37
493082	Ferron Cr. above Ferron lagoons at US 10 crossing	1/23/90	11/21/02	72
493093	Cottonwood Cr. at US 10 crossing in Castle Dale	2/20/90	6/10/98	32
493095	Cottonwood Cr. above Grimes wash	8/25/97	11/20/02	14
493161	Price R. at mouth	6/14/93	7/29/02	22
493165	Price R. near Woodside at US 6 crossing	3/21/90	8/30/01	55
493239	Price R. above Price WWTP at Wellington bridge	5/10/90	8/20/02	25
493253	Gordon Cr. above confluence with Price R.	4/4/90	8/20/02	16
493281	Price R. above Price River coal	2/11/92	8/21/01	70
493283	White R. at US 6 crossing	1/23/90	7/16/02	20
493286	Left fork White R. above USFS boundary	7/24/91	11/7/02	30
493288	Right fork White R. at USFS boundary	7/30/93	1/15/02	19
493309	Price R. below confluence with White R.	8/25/97	10/17/02	14
493332	Grassy Cr. trail above Sunnyside Coal 002	8/1/97	9/19/02	11
495500	Muddy Cr. at old US 24 crossing	4/18/90	9/17/02	70
495530	Muddy Cr. at I 70 crossing	1/23/90	8/21/02	88
495543	Quitchupah Cr. above USFS boundary	8/26/97	8/21/02	10
593148	Mud Cr. Above Scofield	8/25/97	11/21/02	16
593165	Fish Cr. Above Scofield Reservoir	6/10/92	8/21/01	21
593176	Ferron Cr. above Millsite Reservoir	6/4/91	11/21/02	29
EWCD #[2,3]				
1	San Rafael River	1/87	12/01	180
2	Huntington Creek upper	1/87	12/01	180
3	Huntington Creek lower	1/87	12/01	180
4	Cottonwood Creek upper	1/87	12/01	180
5	Cottonwood Creek Bott Lane	1/01	12/01	12
6	Cottonwood Creek above Rock Canyon	1/01	12/01	12
7	Cottonwood Creek lower	1/87	12/01	180
8	Rock Canyon Creek upper	10/90	12/01	138
9	Rock Canyon Creek lower	10/90	12/01	138
10	Ferron Creek upper	1/87	12/01	180
11	Ferron Creek lower	1/87	12/01	180
12	Muddy Creek upper	1/87	12/01	180
13	Muddy Creek above Ivie Creek	1/01	12/01	12
14	Muddy Creek lower	1/87	12/01	180
15	Ivie Creek lower	1/01	12/01	180
16	Grimes Wash upper	1/01	12/01	109
17	Grimes Wash lower	1/01	12/01	12
18	Crandal Canyon Creek upper	1/01	12/01	12
19	Crandal Canyon Creek lower	1/01	12/01	12

1. Only data collected after 1990 is presented.
2. EWCD monitoring is continuing to the present. Only data through December 2001 was used in the assessment of water quality in the WCRW.
3. Flow measurements are also taken at the EWCD locations, and are used in the TMDL.

3.3 Flow Data

The two primary sources of flow data for the watershed are the USGS and the EWCD. As noted in Table 3-2, the EWCD database includes both flow and chemistry data. Additionally, the USGS has been measuring flows throughout the WCRW since the early 1900s. Stream flow monitoring station descriptions and period of record for each USGS location, in each of the three watersheds in the WCRW that has been recently (e.g., 1990-2000) sampled are provided in Tables 3-3, 3-4, and 3-5.

Table 3-3 USGS Flow Gages in the Price River Watershed

Station ID	Station Name	Date		No. of flow readings	Drainage Area (mi^2)
		Start	End		
9310500	Fish Creek above reservoir, near Scofield	6/1/1931	9/30/2001	23317	60.1
9310700	Mud Creek below Winter Quarters Canyon at Scofield	8/22/1978	9/30/2001	6991	29.1
9313000	Price River near Heiner	6/1/1934	9/30/2001	17689	455
9314500	Price River at Woodside	12/1/1945	9/30/2001	17566	1540

Table 3-4 USGS Flow Gages in the San Rafael Watershed

Site No.	Site Name	Date		No. of flow readings	Drainage Area (mi^2)
		Start	End		
9326500	Ferron Creek (upper station) near Ferron	10/1/1911	9/30/2001	24107	138
9328500	San Rafael River near Green River	10/1/1909	9/30/2001	23741	1628

Table 3-5 USGS Flow Gages in the Muddy Creek Watershed

Site No.	Site Name	Date		No. of flow readings	Drainage Area (mi^2)
		Start	End		
9330500	Muddy Creek near Emery	10/1/1910	9/30/2001	20382	105

3.4 Data Use and Limitations

In order to perform a representative assessment of water quality in each watershed in the WCRW, the available water chemistry and flow data were evaluated for limitations, so that the best available data could be used in the TMDL. The following limitations were encountered:

- Limited water chemistry data
- Limited flow data

- Inconsistencies and gaps between measurement dates

These limitations were taken into consideration when characterizing current water quality within each watershed. As described below, these limitations primarily affected the evaluation of water quality in the Price River watershed, as the data collected by the EWCD in the San Rafael River and Muddy Creek watersheds allowed for a more comprehensive evaluation of water quality in these watersheds.

Although data obtained prior to 1990 exists, only data collected from 1990 forward were used in this study. Data was generally not consistently collected prior to 1990, and although these data were considered, it was determined that omission of these data would not result in mischaracterization of water chemistry and hydrology in the WCRW.

3.5 Water Quality Assessment

Water quality in each of the three watersheds in the WCRW was assessed based on the available TDS and flow data previously described. This assessment included an evaluation of the general spatial and temporal patterns in TDS concentrations in surface waters in the watersheds and confirmation of the existing impairment of streams within the watersheds. As discussed in the following sections, water quality assessment was sometimes restricted because of data limitations. The collection of data within the watersheds is an ongoing effort. Any additional data collected will be evaluated for its effect on the TMDLs established in the watersheds. If warranted, the TMDLs may be revised based on new data.

3.5.1 Price River Watershed

Table 3-6 provides a summary of the known water quality data available in the Price River watershed. The locations of the water quality monitoring stations listed in Table 3-6 are shown in Map 10. As shown in Table 3-6, historic TDS concentrations measured in the upper reaches of the watershed were below the criterion of 1,200 mg/L, and the monitored surface waters in the upper reaches are considered to be fully supporting of the agricultural beneficial use classification. Exceedances of the TDS criteria were measured in the middle and lower reaches of the watershed, where surface waters are considered to be only partially supporting or not supporting the agricultural beneficial use classification.

Insert Map 10

The upper portion of the Price River watershed is primarily forest lands, with the typical land uses being livestock grazing and recreation. The middle portion of the Price River watershed is dominated by agriculture with significant irrigation and urban activities. Additionally, there are significant coal bed methane (CBM) reserves in this portion of the Price River watershed which are currently being exploited, as well as coal mines. Mancos Shale, a natural source of salts in the watershed is also prevalent in the middle portion of the watershed. These land uses and geologic characteristics of the middle portion of the watershed account for the noted variation in water quality in the watershed.

Table 3-6 Water Quality Data for the Price River Watershed

Site ID	Description	TDS (mg/L)				No. of samples	Number of Violations	Support[1]
		Min	Max	Mean	Upper 95% Confidence Interval			
493161	Price River at mouth	652	3,442	1,618	1,781	20	14	NS
493165	Price River at Woodside	548	4,866	2,164	2,166	71	57	NS
493239	Price River above Price WWTP in Wellington	408	2,918	1,511	1,933	21	11	PS
493253	Pinnacle Creek above Confluence with Price River[2]	888	4,038	2,470	2,634	12	10	NS
493137	Gordon Creek above Price River confluence	1112	2254	1,765	2183	6	5	NS
493281	Price River above Price River Coal	172	518	297	300	72	0	FS
493283	White River at US 50 crossing	320	420	371	367	20	0	FS
493286	Left fork White River above Right fork White River	182	340	310	319	19	0	FS
493288	Right fork White River above Left fork White River	286	368	326	342	15	0	FS
493309	Price River below confluence with White River	206	374	293	312	10	0	FS
493332	Grassy Trail Creek above Sunnyside Mine[3]	316	538	381	442	10	0	PS
593148	Mud Creek above Scofield	236	906	413	458	11	0	FS
593165	Fish Creek above Scofield Reservoir	168	220	190	193	21	0	FS

[1] NS = Not Supporting; PS = Partially Supporting; FS = Fully Supporting (as listed in the RFP for the TMDL)
[2] While Gordon Creek is listed as the impaired segment, the impairment listing was based on sampling of Pinnacle Creek. However, subsequent sampling of Gordon Creek demonstrates that it is also impaired due to TDS concentrations and Gordon Creek is listed in the draft Utah 2004 303 (d) list of waters.
[3] This segment is listed due to pH (DEQ 2000)

3.5.1.1 Critical Seasonal Variations in TDS Concentrations

Average monthly TDS concentrations and flows measured at STORET monitoring stations Nos. 493281, 493239 and 493165, located in the upper, middle, and lower reaches of the Price River, are shown in

Figures 3-1, 3-2, and 3-3, respectively. Monitoring stations Nos. 49239 and 493165 were chosen as target sites in the Price River watershed.

As shown in Figure 3-1, seasonal variations in flow in the upper reach of the Price River are apparent, but little change in average TDS concentrations occur. The relative consistency in TDS concentrations in the upper reaches of the Price River points to the lack of TDS sources in the upper reaches of the watershed. Figures 3-2 and 3-3 show that TDS concentrations in the middle and lower reaches of the Price River, on average, exceed the water quality criterion throughout most of the year. The exception is average measured TDS concentrations in the spring/early summer when seasonal increases in flow appear to provide a dilution effect on TDS concentrations in the river. These patterns suggest that TDS loading to the Price River occurs throughout the year, influenced seasonally by irrigation diversions and return flows (increasing TDS concentrations) and spring run-off (decreasing TDS concentrations due to dilution).

3.5.1.2 Critical Flow verses TDS Concentrations

The data presented in Figure 3-1 shows that there are no significant seasonal or flow effects on TDS concentrations within the upper reaches of the Price River, confirming the absence of any significant TDS sources in the area. A comparison of Figures 3-1, 3-2 and 3-3 shows that while flow in the Price River decrease in the downstream reaches of the river (below STORET monitoring station 493281), TDS concentrations increase. This pattern points to the effect of irrigation diversions and natural stream losses from the Price River that occurs in the middle and lower reaches of the watershed and the sources (e.g., Mancos Shale) of TDS existing in the area. It also reflects the complex interaction between stream diversions, losses, irrigation return flows, and other inflows, and the resulting effect on water quality in the lower reaches of the Price River. While overall flow in the river is decreasing, it is apparent that surface water and/or groundwater inflows with very high TDS concentrations are entering the river, resulting in the higher TDS concentrations measured at the downstream monitoring stations. Given the complex hydrology within the watershed, the available data does not allow for a meaningful comparison of flow versus TDS concentrations in the lower reaches of the Price River.

3.5.2 San Rafael River Watershed

For purposes of this TMDL study, the San Rafael River watershed was divided into five sub-watersheds. These sub-watersheds are Huntington Creek, Cottonwood Creek, Rock Canyon Creek, Ferron Creek, and the lower San Rafael River. The five target sites established in the San Rafael watershed (see Section 2.2) were located in the downstream reaches of the major drainages in each of these five sub-watersheds. The analysis of sub-watersheds within the San Rafael River watershed was possible due to the amount of data available. By establishing the five target sites in the San Rafael watershed, a more discrete assessment of water quality in the watershed could be performed.

3.5.2.1 Water Chemistry

Tables 3-7 through 3-11 provide a summary of measured water chemistry in the Huntington Creek, Cottonwood Creek, Rock Canyon Creek, Ferron Creek, and the lower San Rafael River sub-watersheds, respectively. The water chemistry data summarized in these tables was collected by both the DEQ and EWCD. The locations of the water quality monitoring stations listed in the tables are shown in Map 11.

As shown in Tables 3-7, 3-8, and 3-10, measured TDS concentrations in the upper reaches of the Huntington Creek, Cottonwood Creek, and Ferron Creek sub-watersheds were below the criterion of 1,200 mg/L, and the monitored surface waters in the upper reaches of these sub-watersheds are considered to be fully supporting of the agricultural beneficial use classification. Exceedances of the TDS criteria were noted in the middle to lower reaches of these sub-watersheds, where Huntington Creek, Cottonwood Creek, and Ferron Creek are considered to be non-supporting of the agricultural beneficial use classification. Similar to the Price River Watershed, the noted variations in water quality in these three sub-watersheds are attributed to land use and geologic characteristics of the sub-watersheds. Land use in the upper reaches of these sub-watersheds is primarily forest, along with some power generation and coal mining in the Huntington Creek sub-watershed, coal mining in the Cottonwood Creek sub-watershed, and CBM activities in the Ferron Creek sub-watershed. The middle and lower reaches of all three sub-watersheds are dominated by agriculture use, with significant irrigation and urban activities. Mancos Shale is also prevalent in the middle and lower reaches of the sub-watersheds.

As shown in Tables 3-9 and 3-11, measured TDS concentrations in Rock Canyon Creek and the San Rafael River have exceeded the TDS criterion throughout the monitored reaches of these waters, and Rock Canyon Creek and the San Rafael River are considered to be non-supporting of the agricultural beneficial use classification. The elevated TDS concentrations in Rock Canyon Creek are attributed to land use activity in the watershed (i.e., agriculture use, with irrigation and urban activities) and the presence of Mancos Shale. Additionally, the Hunter Power Plant is located in the Rock Canyon Creek subwatershed. While there are no existing UPDES permits for the plant, discharge of water to Rock Canyon Creek occurs from plant operations. Recognizing that this discharge needs to be permitted, the Department of Environmental Quality has initiated the permit process. It is expected that the issued permit will include a discharge limit for concentrations of TDS.

Table 3-7 Water Quality Data for the Huntington Creek Sub-watershed

Site ID	Description	TDS (mg/L)				# Samples	Number of Violations	Support [1]
		Min	Max	Mean	Upper 95% Confidence Interval			
493052	Huntington Creek above Lagoons	426	4,768	2,559	3,105	21	15	NS
493053	Huntington Creek above UP&L diversion	172	284	216	222	11	0	FS
EWCD-2	Huntington Creek upper	10	460	220	225	175	0	FS
EWCD-3	Huntington Creek lower	464	6,242	3,241	3,324	174	165	NS
EWCD-18	Crandal Canyon Creek upper	216	536	341	345	47	0	FS
EWCD-19	Crandal Canyon Creek lower	260	664	417	423	51	0	FS

[1] NS = Not Supporting; PS = Partially Supporting; FS = Fully Supporting (as listed in the RFP for the TMDL)

Table 3-8 Water Quality Data for the Cottonwood Creek Sub-watershed

Site ID	Description	TDS (mg/L)				# Samples	Number of Violations	Support[1]
		Min	Max	Mean	Upper 95% Confidence Interval			
493093	Cottonwood Creek above Castle Dale Lagoons	324	2,202	1,033	1,238	22	7	NS
493095	Cottonwood Creek above Grimes Wash	196	298	238	246	10	0	FS
EWCD-4	Cottonwood Creek upper	108	460	249	255	175	0	FS
EWCD-5	Cottonwood Creek at Bott Lane	690	1,800	1,113	1,208	12	5	NS
EWCD-6	Cottonwood Creek above Rock Canyon Creek	1,600	3,200	1,992	2,162	12	12	NS
EWCD-7	Cottonwood Creek lower	348	4,750	2,325	2,355	175	163	NS
EWCD-16	Grimes Wash upper	440	5,010	1,252	1,280	109	37	NS
EWCD-17	Grimes Wash lower	602	2,800	1,549	1,570	96	71	NS

[1] NS = Not Supporting; PS = Partially Supporting; FS = Fully Supporting (as listed in the RFP for the TMDL)

Table 3-9 Water Quality Data for the Rock Canyon Creek Sub-watershed

Site ID	Description	TDS (mg/L)				# Samples	Number of Violations	Support[1]
		Min	Max	Mean	Upper 95% Confidence Interval			
EWCD-8	Rock Canyon Creek upper	892	5,660	3,411	3,475	91	86	NS
EWCD-9	Rock Canyon Creek lower	696	7,750	3,583	3,624	135	134	NS

[1] NS = Not Supporting; PS = Partially Supporting; FS = Fully Supporting (as listed in the RFP for the TMDL)

Table 3-10 Water Quality Data for the Ferron Creek Sub-watershed

Site ID	Description	TDS (mg/L)				# Samples	Number of Violations	Support[1]
		Min	Max	Mean	Upper 95% Confidence Interval			
493080	Ferron Creek below Ferron Lagoons	958	1,678	1,318	2,316	2	1	FS
493082	Ferron Creek above Ferron Lagoons	308	958	758	832	21	0	FS
593176	Ferron Creek above Millsite Reservoir	214	366	286	291	23	0	FS
EWCD-10	Ferron Creek upper	48	756	350	360	175	0	FS
EWCD-11	Ferron Creek lower	448	7,260	2,692	2,734	174	164	FS

[1] NS = Not Supporting; PS = Partially Supporting; FS = Fully Supporting (as listed in the RFP for the TMDL)

Table 3-11 Water Quality Data for the Lower San Rafael River Sub-watershed

Site ID	Description	TDS (mg/L)				# Samples	Number of Violations	Support[1]
		Min	Max	Mean	Upper 95% Confidence Interval			
493029	San Rafael at U24 crossing	492	3,924	2,170	2,868	29	26	NS
493034	San Rafael at Buckhorn road	780	3,030	1,803	2,003	11	8	NS
EWCD-1	San Rafael River lower	480	5,070	2,549	2,580	175	164	NS

[1] NS = Not Supporting; PS = Partially Supporting; FS = Fully Supporting (as listed in the RFP for the TMDL)

Given the measured concentrations of TDS in Huntington Creek, Cottonwood Creek, Rock Canyon Creek, and Ferron Creek, all which drain to the San Rafael River, the measured concentrations of TDS in the San Rafael River were not unexpected. As shown in Table 3-11, the mean concentration of TDS in the San Rafael River decreases in the lower reach of the river. This may be attributable to water inflows of lower TDS concentrations, consistent with the lack of any significant TDS sources in the lower San Rafael River watershed.

Insert Map 11

3.5.2.2 Critical Seasonal Variations in TDS Concentrations

Monitoring stations EWCD-03 (Lower Huntington Creek), EWCD-07 (Lower Cottonwood Creek), EWCD-09 (Lower Rock Canyon Creek), EWCD-11 (Lower Ferron Creek) and Storet Monitoring Station 493029 (San Rafael at U24 crossing) were chosen as target sites for TMDL analysis in the San Rafael River watershed. Monitoring stations EWCD-03, EWCD-07, EWCD-09, and EWCD-11 were chosen as target sites because the measured water chemistry and flows at these locations reflect the effects of all TDS sources and hydrological processes (i.e., irrigation diversions, return flows, groundwater and surface water inflows) in their respective sub-watersheds. STORET monitoring station 493029 was chosen as a target site because the measured water chemistry and flows at this location reflect the effects of all significant TDS sources and hydrological processes within substantially the entire San Rafael River watershed.

The average monthly TDS concentrations and flows measured at monitoring stations EWCD-03, EWCD-07, EWCD-09, EWCD-011 are shown in Figures 3.4 through 3.7, respectively. Each of these figures shows similar relationships between flow and TDS concentrations attributed to irrigation activities and spring runoff occurring in the sub-watersheds. First, a decrease in average measured flow associated with an increase in average TDS concentration is noted in the month of April. This is followed by a significant increase in flows associated with a significant decrease in TDS concentrations; the highest average flows and, except for Huntington Creek, the lowest average TDS concentrations occurring in June. Average monthly flows then generally decrease, with some variation, associated with generally increasing TDS concentrations, with some variation over the months of July through October. Flows in the streams appear to be generally consistent over the months of November through February, rising or falling again in March.

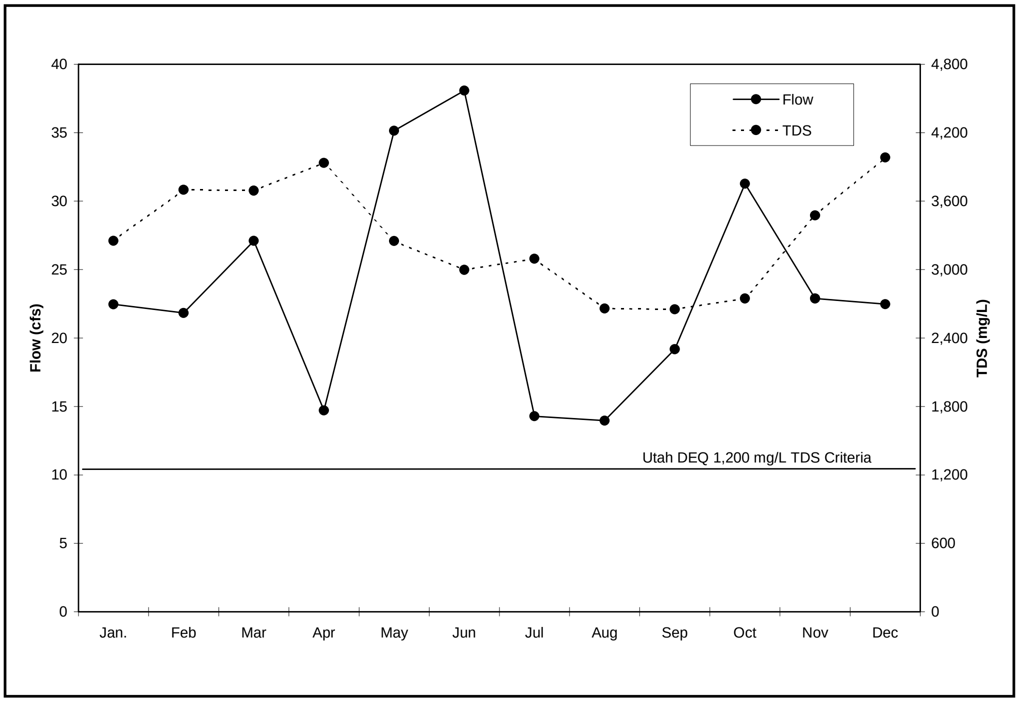

Figure 3-4 Average Monthly Flow and TDS for EWCD-03 (Lower Huntington Creek)

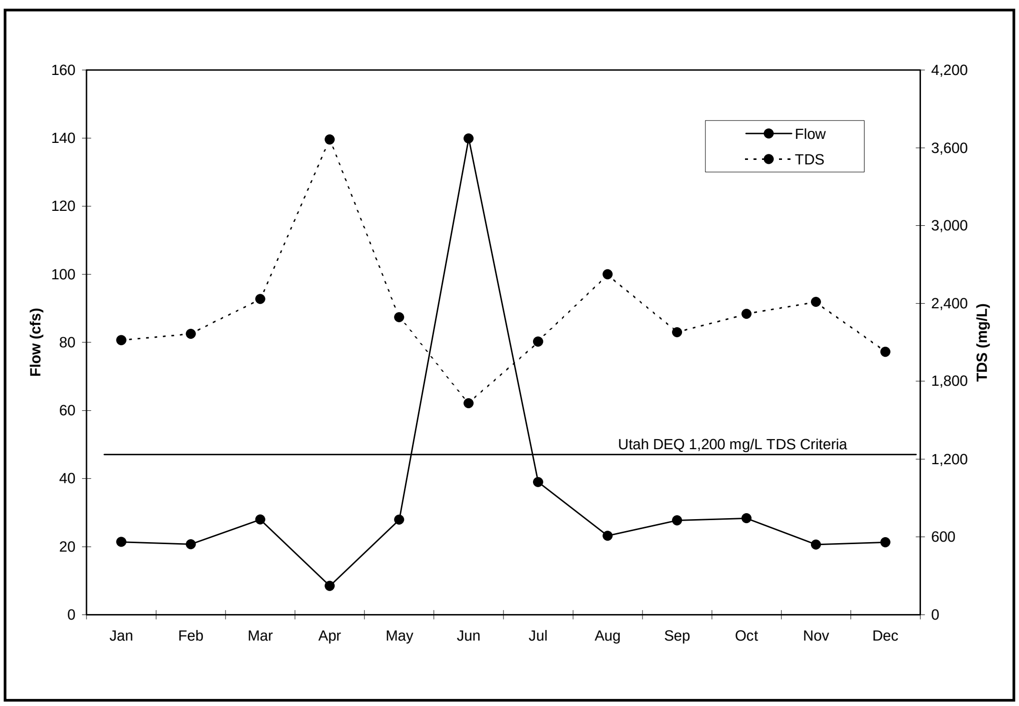

Figure 3-5 Average Monthly Flow and TDS for EWCD-07 (Lower Cottonwood Creek)

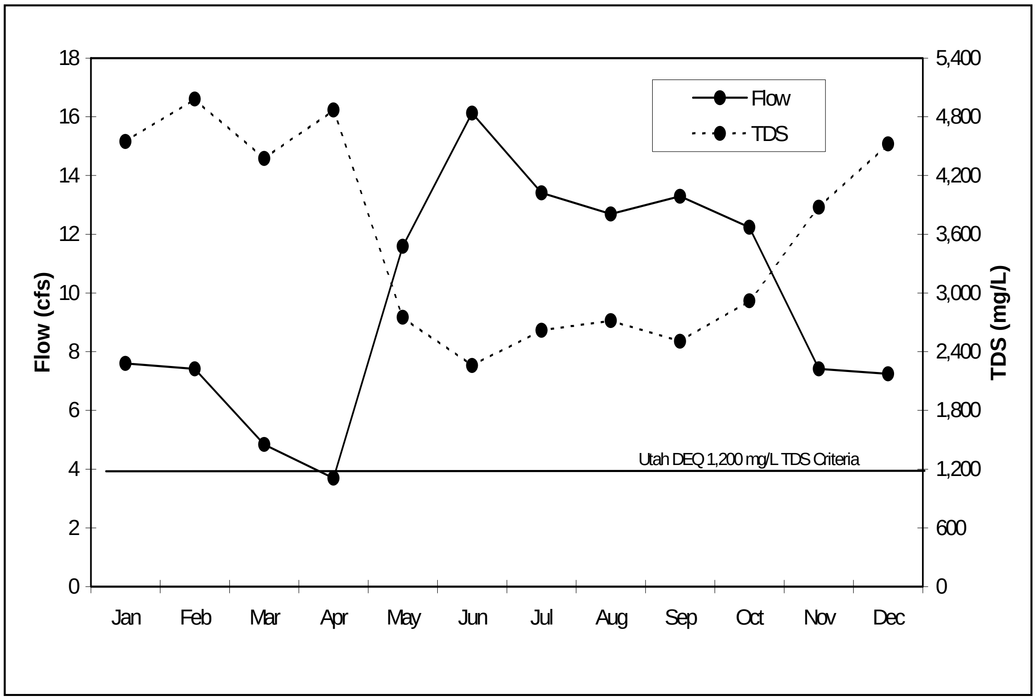

Figure 3-6 Average Monthly Flow and TDS for EWCD-09 (Lower Rock Canyon Creek)

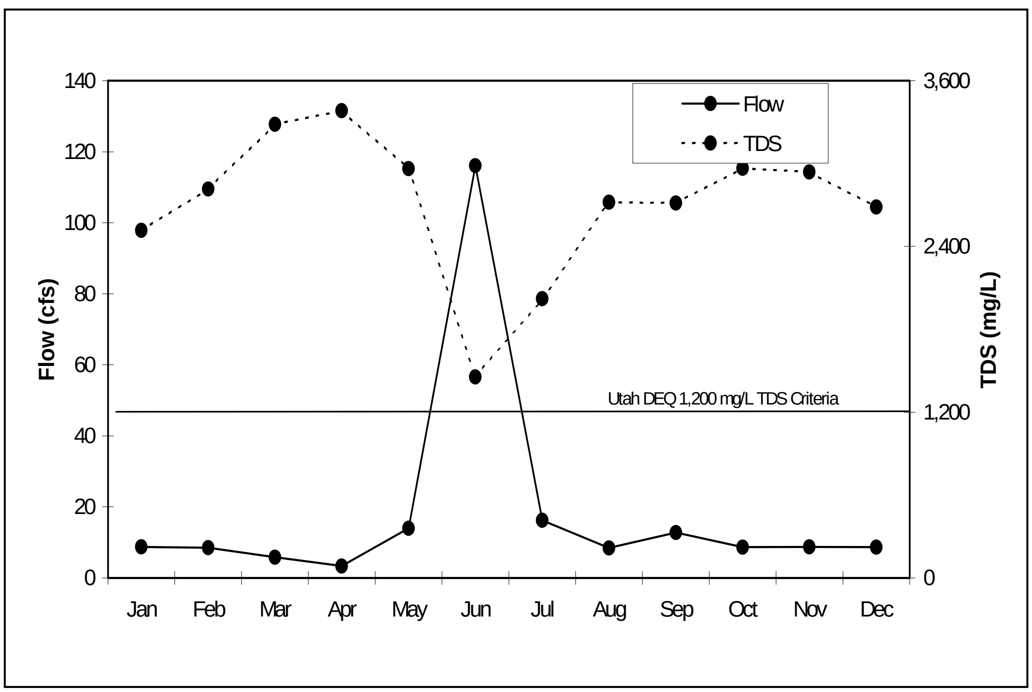

Figure 3-7 Average Monthly Flow and TDS for EWCD-11 (Lower Ferron Creek)

The decrease in average flow and increase in average TDS concentrations occurring in April may be due to the first significant diversions of surface water for irrigation during the year and associated high TDS concentration return flows. The decreased TDS concentration measurements in June are indicative of the seasonal dilution effect of increased flows occurring in this month. Between July and October, stream flow and measured TDS concentrations are subject to complex interactions between stream diversions, losses, irrigation return flows and other inflows to the streams. The more consistent flow patterns and associated TDS concentrations over the months of November through February are consistent with the decrease in runoff and irrigation activity over these months. Although seasonal variations in TDS concentrations are shown, it is noted that there is no one critical season for high TDS concentrations in Huntington, Cottonwood, Rock Canyon, and Ferron Creeks, as the average measured TDS concentrations in these creeks consistently exceed the TDS criterion of 1,200 mg/L over the entire year.

The average monthly TDS concentrations and flows measured at the STORET monitoring station 493029 are shown in Figure 3-8. The variations in average flow and TDS concentrations measured in the San Rafael River at this location reflect the collective contribution of inflows to the San Rafael River from Huntington, Cottonwood, Rock Canyon, and Ferron Creeks. As with these tributaries, it is noted that there is no one critical season for high TDS concentrations in the San Rafael River, as measured TDS concentrations in the lower San Rafael River consistently exceed the TDS criterion of 1,200 mg/L over the entire year.

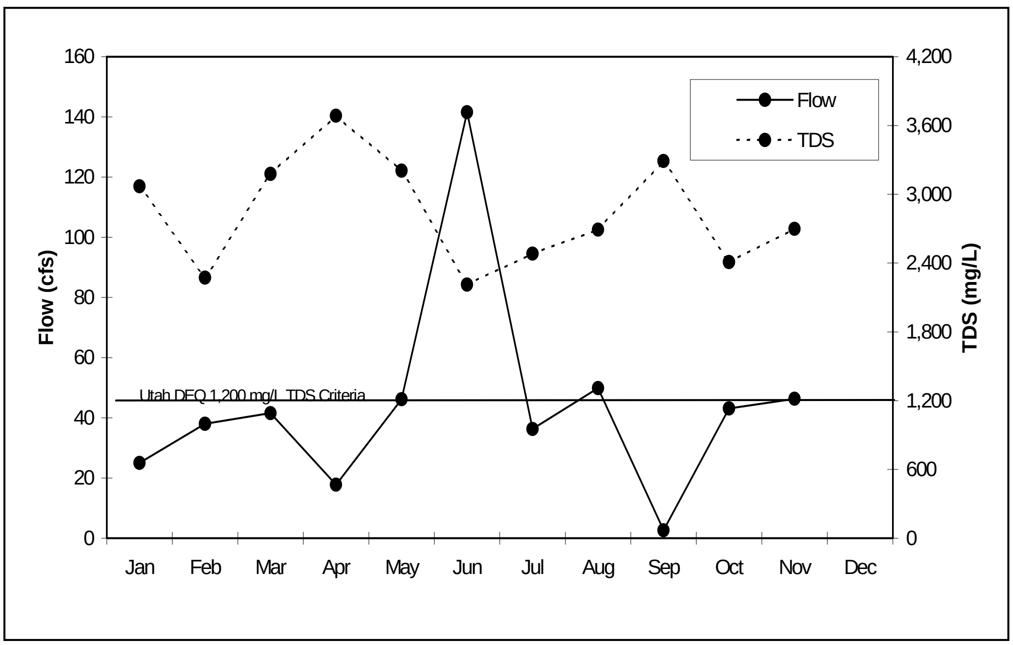

Figure 3-8 Average Monthly Flow and TDS for 493029 (San Rafael River at US 24 Crossing)

3.5.2.3 Critical Flow versus TDS Concentration

Figures 3-9 through 3-13 are plots of TDS concentrations verses flow at monitoring stations EWCD-03 through EWCD-11 and STORET monitoring station 493029, respectively. These plots show the trend of increasing TDS concentration with decreasing flow and the dilution effect of decreasing TDS concentration at high flows in each of the measured streams. The TDS concentrations are the highest during low flow conditions when it may be expected that groundwater inflows (including long-term irrigation return flow) with elevated TDS concentrations provide the majority of streamflow. The elevated TDS concentrations in groundwater are attributed to contact with the Mancos Shale (Laronne 1977), which is prevalent in the middle and lower portions of the Huntington Creek, Cottonwood Creek, Rock Canyon Creek, and Ferron Creek sub-watersheds. Although TDS concentrations decrease with increasing flows, TDS concentrations occur above the TDS water quality criterion throughout most of the range of flows. The consistently high TDS concentrations throughout the range of normal flows are attributed to continual loading from natural sources, irrigation return flows, and other inflows occurring over the range of these flows. As a practical matter, there is no critical flow, within the range of normally expected flows, above which the TDS criterion is attained in these stream reaches.

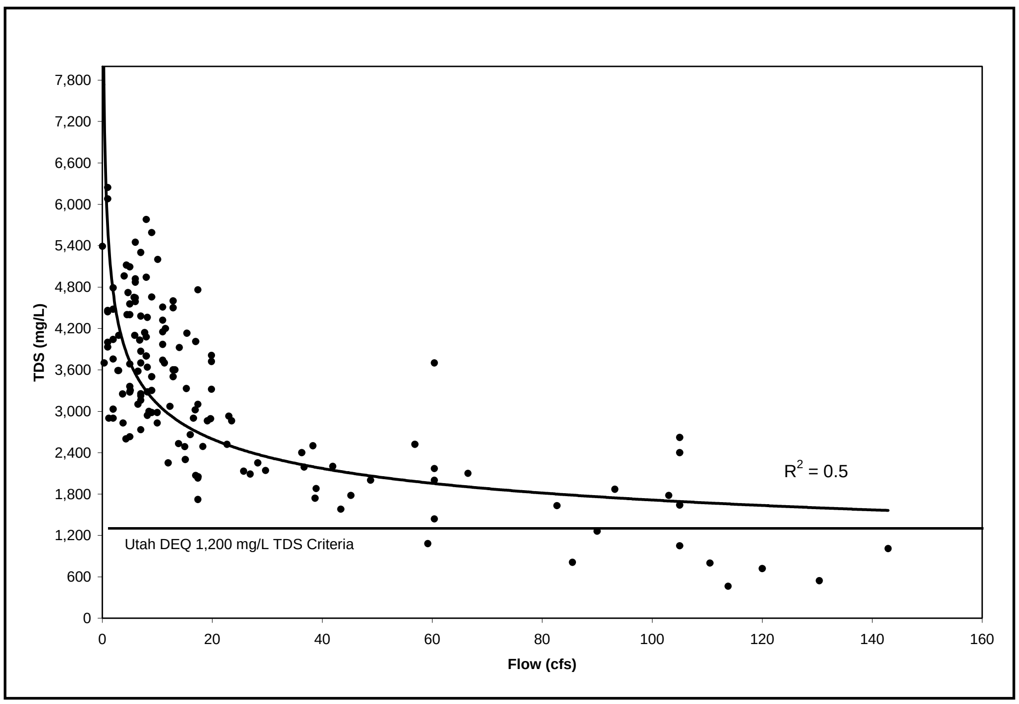

Figure 3.9 Flow verses TDS Regression Plot for EWCD-03 (Lower Huntington Creek)

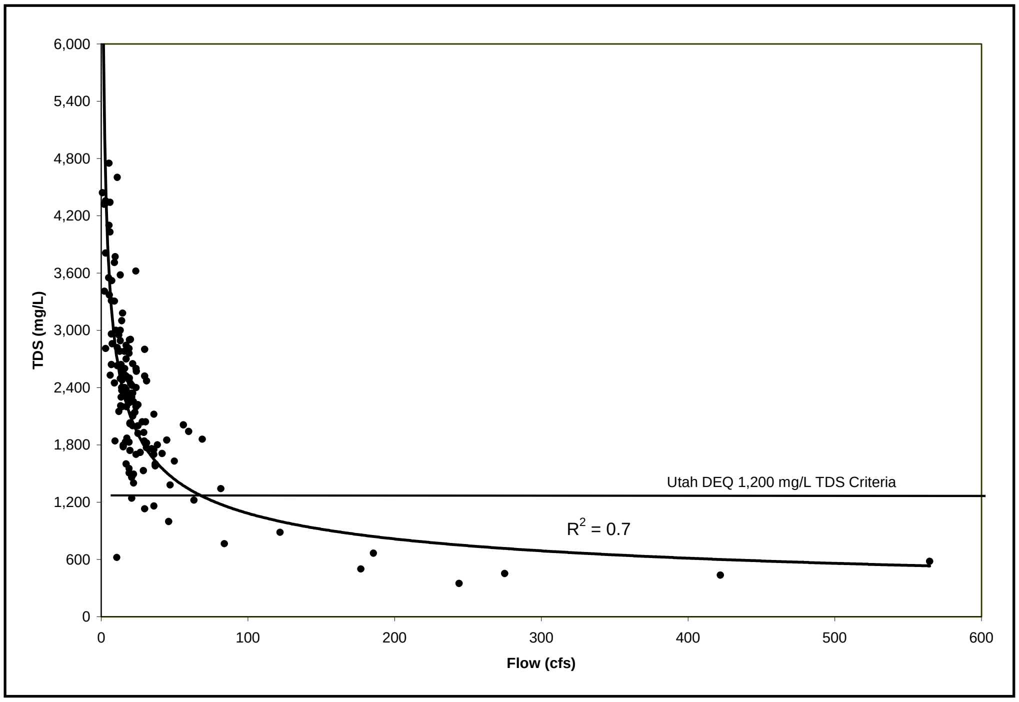

Figure 3-10 Flow verses TDS Regression Plot for EWCD-07 (Lower Cottonwood Creek)

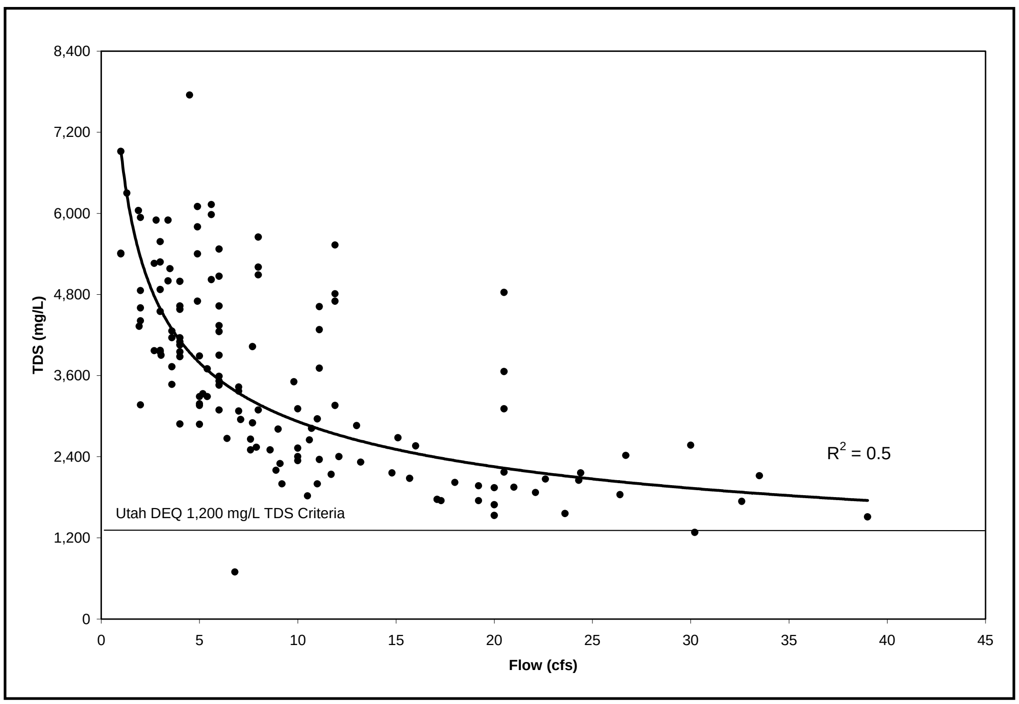

Figure 3-11 Flow verses TDS Regression Plot for EWCD-09 (Lower Rock Canyon Creek)

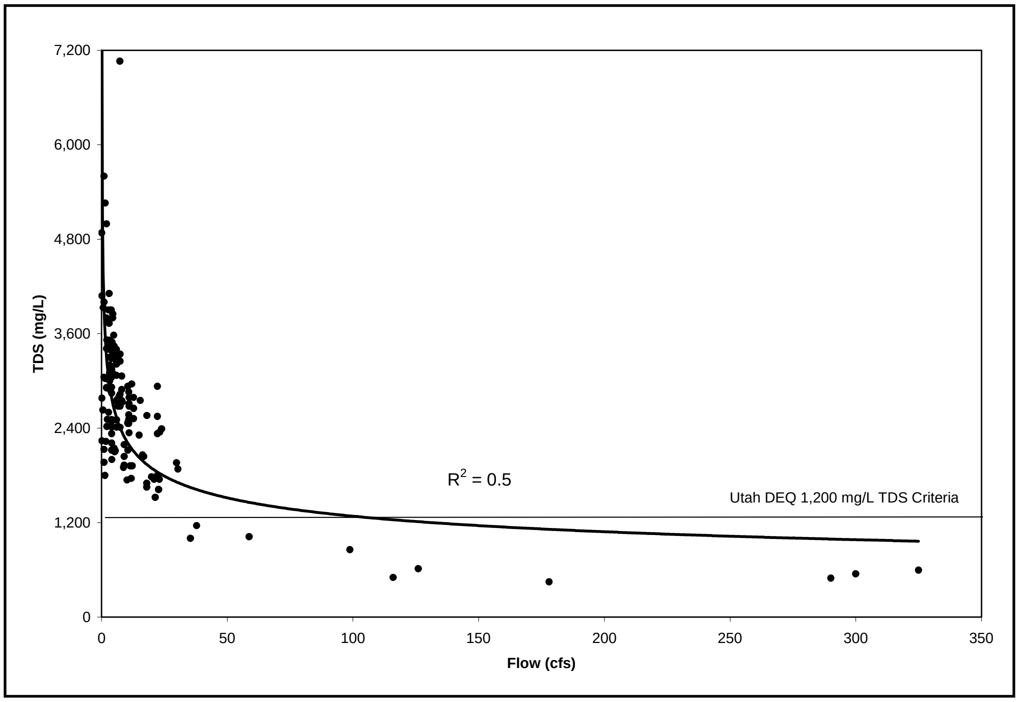

Figure 3-12 Flow verses TDS Regression Plot for EWCD-11 (Lower Ferron Creek)

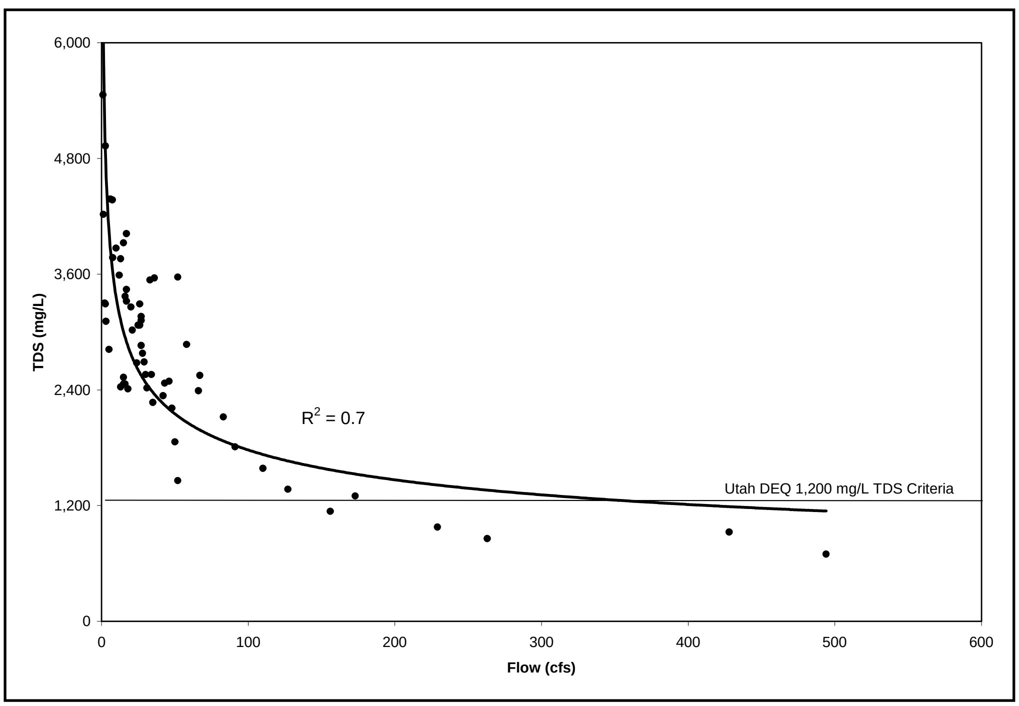

Figure 3-13 Flow verses TDS Regression Plot for 493029 (San Rafael River at US 24 Crossing)

3.5.3 Muddy Creek Watershed

Table 3-12 provides a summary of the measured water chemistry in the Muddy Creek watershed. The locations of the water quality monitoring stations listed in Table 3-12 are shown in Map 12. As shown in Table 3-12, historic TDS concentrations measured in the upper reaches of the watershed were below the criterion of 1,200 mg/L, and the monitored surface waters in the upper reaches are considered to be fully supporting of the agricultural beneficial use classification. Exceedances of the TDS criteria were measured in the middle and lower reaches of the watershed, where surface waters are considered to be only partially supporting or non- supporting of the agricultural beneficial use classification.

The noted variations in water quality in the Muddy Creek watershed are attributed to land use and geologic characteristics of this watershed. The upper portion of the Muddy Creek watershed is primarily BLM and USFS administered lands. There is also some coal mining that occurs in this portion of the watershed. The middle portion of the Muddy Creek watershed is dominated by irrigated agriculture and urban areas. Mancos Shale is also prevalent in the middle portion of the watershed. These land use and geologic characteristics of the watershed account for the noted variation in water quality throughout the watershed.

Table 3-12 Water Quality Data for the Muddy Creek Watershed

Site ID	Description	TDS (mg/L)				Count	Number of Violations	Support[1]
		Min	Max	Mean	Upper 95% Confidence Interval			
495500	Muddy Creek at Old U24 crossing	806	6,080	3,276	3,736	63	57	NS
495530	Muddy Creek at I70 crossing	386	5,332	1,702	1,835	74	53	NS
495543	Quitchupah Creek above USFS boundary	466	852	675	724	10	0	FS
EWCD-12	Muddy Creek upper	60	648	274	282	175	0	FS
EWCD-13	Muddy Creek above Ivie Creek	620	4,900	2,284	3,531	12	4	NS
EWCD-14	Muddy Creek lower	416	4,580	1,829	1,735	173	141	NS
EWCD-15	Ivie Creek	740	3,100	1,711	1,925	12	10	NS

[1] NS = Not Supporting; PS = Partially Supporting; FS = Fully Supporting (as listed in the RFP for the TMDL)

Insert Map 12

3.5.3.1 Critical Seasonal Variations in TDS Concentrations

Average monthly TDS concentrations and flows measured at STORET monitoring station 495500 (Muddy Creek at Old U24 Crossing) and monitoring station EWCD-14 (Lower Muddy Creek) are shown in Figures 3-14 and 3-15, respectively. Figures 3-14 and 3-15 show a generally similar seasonal pattern of average monthly flows and associated TDS concentrations attributed to similar irrigation activities and runoff patterns as described for the sub-watersheds in the San Rafael watershed. As with the sub-watersheds in the San Rafael watershed, although seasonal variations in TDS concentrations are shown, it is noted that there is no one critical season for high TDS concentrations in these reaches of Muddy Creek, as the average measured TDS concentrations consistently exceed the TDS criterion of 1,200 mg/L over the entire year.

3.5.3.2 Critical Flow verses TDS Concentrations

Figures 3-16 and 3-17 are plots of measured TDS concentrations verses flow at STORET monitoring station 495500 and monitoring station EWCD-14, respectively. These plots show a trend of increasing TDS concentration with decreasing flow and a dilution effect of decreasing TDS concentrations at high flows at each station. TDS concentrations are the highest during low flow conditions when it may be expected that groundwater inflows (including long-term irrigation return flow) with elevated TDS concentrations provide the majority of streamflow. The elevated TDS concentrations in groundwater are attributed to contact with the Mancos Shale (Laronne 1977), which is prevalent in the middle portion of the watershed. Although TDS concentrations decrease with increasing flows, TDS concentrations occur above the TDS water quality criterion throughout most of the range of flows. The consistently high TDS concentrations throughout the range of normal flows are attributed to the continual inflow of groundwater, irrigation return flows, and other inflows to the stream occurring over the range of these flows. As a practical matter, there is no critical flow, within the range of normally expected flows, above which the TDS criterion is attained in these stream reaches.

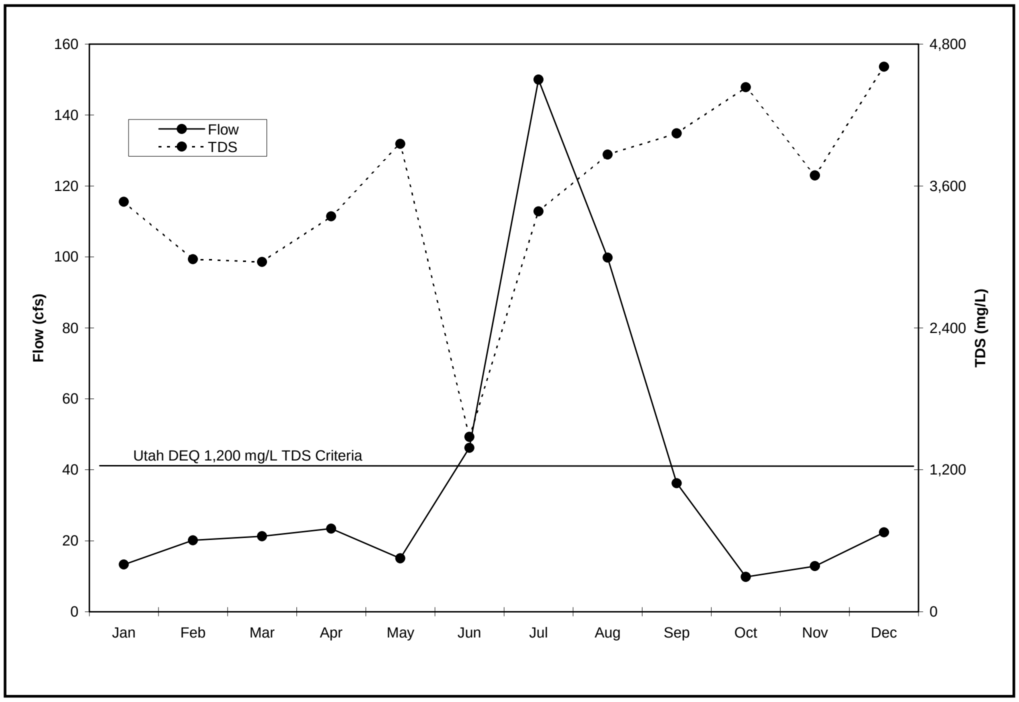

Figure 3-14 Average Monthly Flow and TDS for 495500 (Muddy Creek at Old US 24 Crossing)

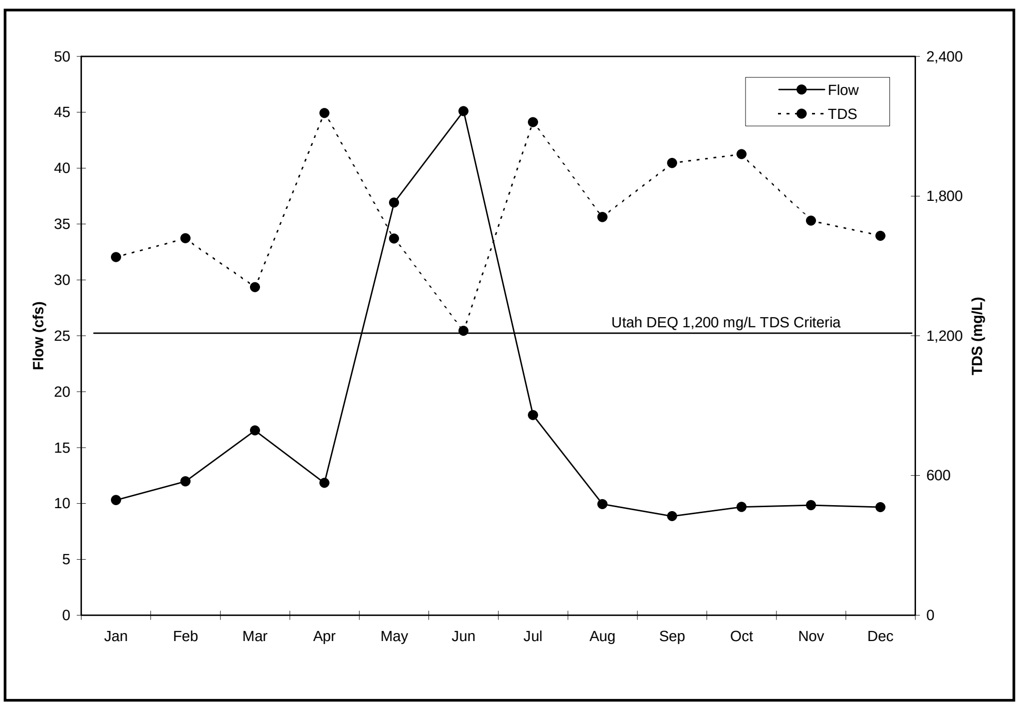

Figure 3-15 Average Monthly Flow and TDS for EWCD-14 (Lower Muddy Creek)

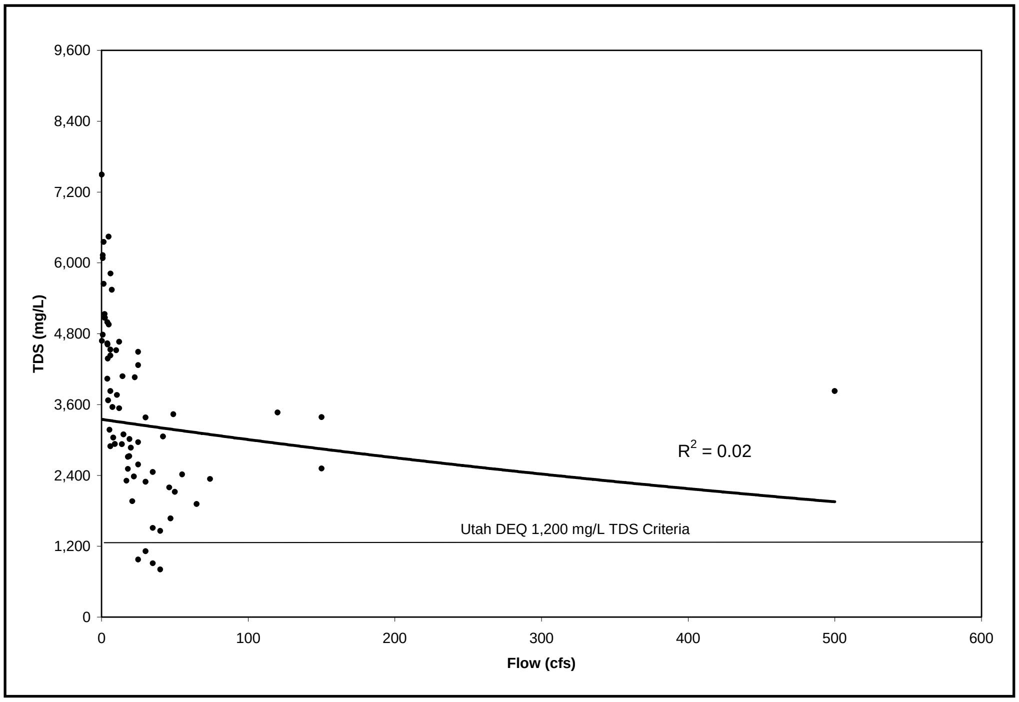

Figure 3-16 Flow verses TDS Regression Plot for 495500 (Muddy Creek at Old US 24 Crossing)

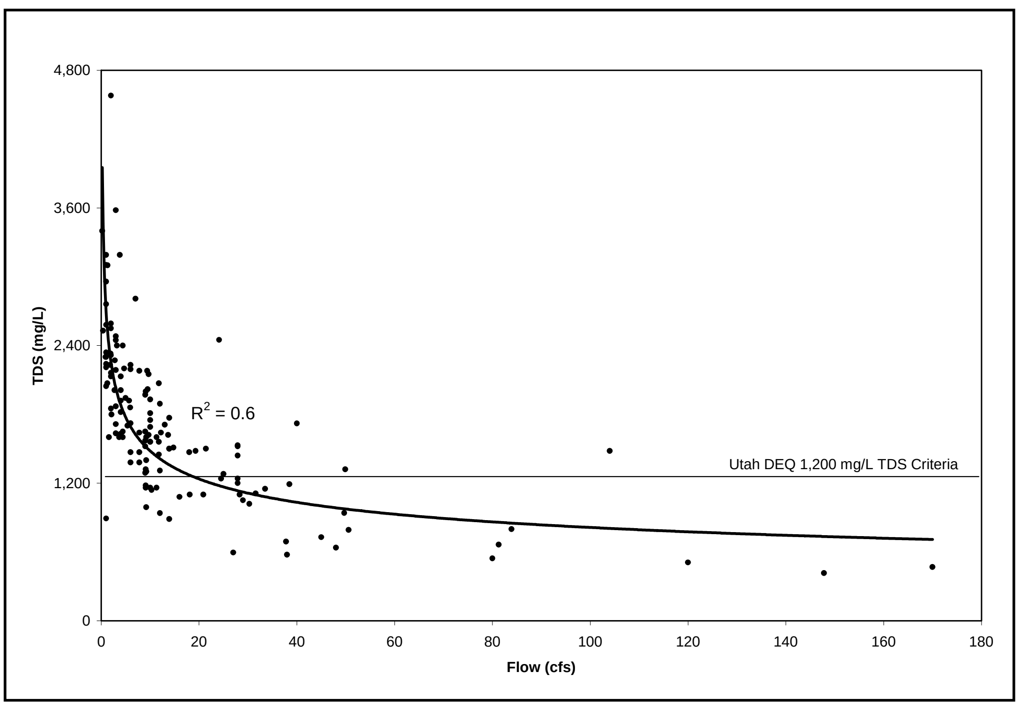

Figure 3-17 Flow verses TDS Regression Plot for EWCD-14 (Lower Muddy Creek)

3.5.4 Summary

The majority of the water quality standards violations occur in the middle and lower portions of the Study Area watersheds where agriculture and rangeland are the predominant land use. As discussed in Section 3.1, with only limited exceptions, TDS is the constituent of concern for the WCRW. The available data indicates that Grassy Creek, the sole segment listed for impairment from pH, should not be listed as impaired. Furthermore, there have not been any exceedances of the DO standard in any stream segment in the WCRW in the last three years. Segments listed as impaired due to DO will be removed in the next 305(b) listing. Based on the limited exceedances of the dissolved iron concentrations and the lack of any identified sources, all stream segments listed as impaired from iron have been delisted in the draft Utah 2004 303 (d) list of waters.

The primary factors in increased TDS loads in the middle and lower reaches of the Price, San Rafael, and Muddy Creek watersheds are from agricultural irrigation practices, surface runoff, and natural geological loadings. Increased surface run-off, and loading of TDS, is also associated with current irrigation practices. Irrigation water percolating through the soil and shale dissolves salts, principally carbonates and sulfates, and transports them to the natural drainages (Laronne 1977). Groundwater moving through the Mancos Shale formation, already affected by soils containing elevated salt levels, picks up additional salts from the shale and discharges the high TDS concentration into streams. Due to different geology and landuses, the upper portions of each of the watersheds generally have insignificant salt loadings relative to the downstream reaches. Specific non-point and point sources for each of the target locations are discussed in greater detail in Sections 4 and 6.

4.0 SOURCE ASSESSMENT

Data evaluation shows that both point and non-point sources are contributing TDS load to streams within the WCRW. The evaluation also shows non-point source pollution is the leading cause of excessive TDS concentrations within the watershed. Past work in the area (BOR and SCS 1993) estimates that irrigation, waste discharge, and natural geologic loadings results in an increase in TDS from approximately 300 mg/L above areas of agricultural irrigation use to greater than 2,000 mg/L below these areas.

4.1 Municipal and Industrial Sources

There are both municipal and industrial sources of TDS loading in the WCRW Study Area. Past work in the Colorado River Basin has estimated that municipal and industrial sources can increase salt loading by approximately 100 tons per 1,000 people per year (BOR 2001). Permitted municipal source discharges in the Study Area are associated with wastewater treatment facilities. Permitted industrial source discharges are associated with coal mine operations and power plants. These permitted point source discharges and discharge data are shown in Tables 4-1 and 4-2.

Wastewater treatment facilities located in Price, Huntington and Castle Dale contribute TDS load to the Price River and Huntington and Cottonwood Creeks, respectively. However, the flow from these treatment plants is relatively small and the loads are limited (see Tables 4-1 and 4-2, permit numbers UT0021814, UT0021296, and UT0023663). General surface disturbance and run-off from urban areas, as well as leakage from municipal water supply lines also contributes non-point source loadings of TDS. Runoff rates and flows from urban areas can be 20 percent more than the runoff generated from grassland areas due to the many impervious surfaces in urban areas such as roads, buildings, and parking lots. Along with the possibility for additional erosion of high salt content soils, urban runoff can also contain road salts and other soluble materials that may contribute loading to the WCRW streams (Texas Non-Point Source Book 2003).

Coal mining activities can increase salts through the leaching of spoil materials, groundwater discharge, or erosion of disturbed surface material. Point source discharges are possible from the discharge of dewatering effluents, and from other controlled sources. Non-point discharges can also occur from uncontrolled sources and from increased surface disturbances. A study completed by USGS (1986b) observed that water from mines in the Book Cliffs area of the Price River watershed area contain TDS ranging from 800-1,600 mg/L, while water from mines in the coal resource areas of the San Rafael River watershed contain TDS concentrations of 50-750 mg/L. Most mining operations discharge relatively low annual loads of TDS into streams (see Tables 4-1 and 4-2).

Table 4-1 NPDES Permit Holders, Permit Numbers, and Locations in the WCRW[1]

PERMITEE[2]	PERMIT #	ISSUED	EXPIRES	FACILITY LOCATION
Andalex-West Ridge	UTG040023*	N/A	N/A	PO Box 902, Price
Andalex-Centennial	UTG040008*	9/01/98	4/30/03	PO Box 902, Huntington
Andalex-Wildcat	UTG040007*	6/01/98	4/30/03	PO Box 902, Price
Ark Land Company	UT0025453	7/31/02	7/31/07	18 miles east of Helper
Canyon Fuel-Banning	UTG040011*	5/29/98	4/30/03	PO Box 1029, Wellington
Castlegate Central Processing	UT0025437*	1/14/02	1/31/07	11 miles north of Helper
Castle Valley Special SSD	UT0023663	7/11/00	7/31/05	86 South First East, Castle Dale
Castle Valley SSD- Huntington	UT0021296	11/18/99	11/30/04	PO Box 877, Castle Dale
Consolidation Coal Company Emery Mine	UT0022616	6/17/99	6/30/04	PO Box 527, Emery
Co-Op Mining Company	UT040006	5/01/98	4/30/03	Bear/Trail Canyon Mines, Huntington
Cyprus Plateau Mining-Willow Creek	UTG040012*	1/12/00	4/30/03	847 Northwest Highway 191, Helper
East Carbon Water Treatment Plant	UTG640012*	5/08/98	4/31/03	Whimore Canyon above East Carbon
Emery Water Treatment	UTG640030*	5/08/98	5/31/03	Castle Dale
Ferron Sewerage System	UT0020052**	5/27/99	5/31/04	PO Box 820, Ferron
Genwal Resources	UT0024368**	8/07/95	8/31/05	PO box 1077, Price
Hiawatha Coal Company	UT0023094	9/09/99	9/30/04	PO Box 1201, Huntington
Horse Canyon Mine	UTG040013*	5/20/98	4/30/03	31 North Main St., Helper
Interwest Mining Co Des Be Dov	UTG040022	6/16/98	4/30/03	7 Miles NE of Castle Dale, Huntington
JW Operating Corp.	UT0025488*	N/A	N/A	Soldier Creek Canyon
Lodestar Energy - Horizon	UTG040019	5/04/99	4/30/03	H.C. Box 370, Helper
Lodestar Energy-Scofield	UTG040021*	8/07/98	4/30/03	Scofield Route, Helper
Mountain Coal Co.	UTG040004*	5/29/98	4/30/03	C/O Blackhawk Engineering, Wellington
Orangeville Water Treatment Plant	UTG640031*	5/08/98	5/31/03	NW of Orangeville, Castle Dale
Pacificorp-Carbon Plant	UT0000094	11/30/01	11/30/06	Hwy. 67191, 3 Miles North of Helper
Pacificorp-Deer Creek Coal	UT0023604**	11/18/02	12/31/07	Hwy. 31, 7 miles S. of Huntington
Pacificorp-Trail Mountain	UTG040003*	6/25/93	4/30/03	Sec 25 T17S R6E Alb&M, Orangeville
Pacificorp-West Mine	UT0023728*	1/22/03	12/31/07	PO Box 310, Huntington
Plateau Mining	UT0023736*	12/21/01	12/31/06	Star Point, Price
Price City Water Treatment Plant	UTG640035*	N/A	N/A	Price Canyon Highway 6, Price
Price River Water Improvement District	UT0021814	12/31/01	12/31/06	265 North Fairgrounds Road, Price
Price River Water Treatment Plant	UTG640034*	N/A	N/A	432 West 600 South, Price
Savage Industries	UTG040005**	5/29/98	4/30/03	Route 1 Box 146-H5, Wellington
Star Point Refuse Pile	UTG040025*	8/06/02	4/30/03	Sec. 10&15,T15S, R8E, Wattis
Sunnyside Cogeneration	UT0024759*	8/01/02	7/31/07	1 Power Plant Road, Sunnyside
Talon Resources Inc.	UT0025399	8/24/01	8/31/06	375 South Carbon Ave., A-10, Price
Utahamerican Energy	UTG040024*	N/A	N/A	Lila Canyon, Price
Wal-Mart Supercenter	UTR100812*	N/A	N/A	255 South Highway 55, Price

[1] CBM belowground discharge is not regulated under the UPDES program.
[2] There are two additional power plants (Hunter and Huntington) that are in the process of being permitted for discharge.
***** No data available for this location from USEPA's PCS Environmental Warehouse Internet Database
** Three or less data observations available for this location from USEPA's PCS Environmental Warehouse Internet Database

Table 4-2 NPDES Permit Numbers, Flow, and TDS Data in the WCRW

Permittee[1] Name/Permit Number	Flow (cfs) Design Flow Rate	Flow (cfs) Existing Flow Mean	Flow (cfs) Existing Flow Range	TDS (mg/L) Existing TDS Mean	TDS (mg/L) Existing TDS Range	Load Existing Annual Load[2] (tons/year)	Load Waste Load[3] (tons/year)
Ark Land Company (UT0025453)	0.046	0.020	7.74×10^{-9} - 0.03	567	531-625	8	30
Canyon Fuel - SUFCO (UT0022918)	1.55	4.07	0.03-8.67	794	221-1,449	2,500	10,044
Castle Valley Special SSD (UT0023663)	0.152	0.6	0.31- 1.04	1,513	1,410-1,610	730	1278
Castle Valley SSD – Huntington (UT0021296)	0.619	3.56×10^{-7}	2.63×10^{-7} – 4.33×10^{-7}	2,738	2,400-3,205	0.001	730
Ferron Lagoons- Ferron (UT0020052)	0.84	0.81	0.57-0.96	1195	1070-1320	95	986
Consolidation Coal – Emery (UT0022616)	0.879	0.31	0.11-0.57	4,177	2,460-5,048	1,095	1,104
Co-Op Mining Company (UT040006)	N/A	0.06	1.42×10^{-4} – 0.21	594	296-998	35	670
Hiawatha Coal Company (UT0023094)	0.981	0.23	4.23×10^{-4} – 1.55	705	677-740	146	941
Interwest Mining Co Des Be Dov (UTG040022)	371.4	1.75×10^{-8}	9.28×10^{-9} – 3.09×10^{-8}	10,347	9,533-11,885	0.0002	NA[4]
Lodestar Energy – Horizon (UTG040019)	N/A	4.77×10^{-4}	7.74×10^{-6} – 0.89	382	317-482	258	1035
Pacific – Carbon Plant (UT0000094)	0.433	0.50	3.25×10^{-7} – 8.05×10^{-7}	298	190-510	146	552
Pacificorp – Trail Mountain (UTG040003)	N/A	0.08	0.01 – 0.13	3,035	1,452-7,070	233	138
Price River Water Imp. Dist (UT0021814)	6.2	2.17	1.70×10^{-6} – 2.48×10^{-6}	1,061	899-1,190	2,190	7,304
Talon Resources Inc. (UT0025399)	0.487	9.76×10^{-3}	2.77×10^{-3} – 0.02	327	157-628	3	89

[1] Although there are additional permitted discharges in the WCRW, flow and TDS data for at least four sampling periods is available from USEPA's PCS Environmental Warehouse Internet Database only for the locations listed
[2] Existing annual load from Section 6.4.1
[3] Waste load is calculated based on proposed permit limits as discussed in Section 6.4.3
[4] Design flow is based on the 25 year 6-hour storm event only

An additional industrial activity in the Study Area is development of coal bed methane (CBM). The source coals for CBM are generally located in marine-derived formations such as the Mancos Shale, and development and production of CBM wells results in production of high saline waters, which are typically disposed of through evaporation and deep-well injection. Coal bed methane development and production activities first began in the Study Area in 1990, with more significant activity beginning in 1993-1994 in the Ferron Coals located in the Price River watershed. Water production from development of CBM wells and deep well injection of produced water (produced water was injected into the Navajo and Wingate formations) peaked in the Study Area in 2001 and is now declining. (Hunt 2003)

The effects of CBM development were evaluated on an annual and monthly basis in the San Rafael and Price River watersheds. Any effects were assumed to occur by movement of high saline water into the surface streams as a result of development and production of the CBM wells. The evaluation was accomplished by comparing available measured surface water chemistry over time (pre-CBM to current), looking for any increasing trend in measured TDS concentrations in surface streams that might be attributable to CBM activity. While the analysis of surface water chemistry did not indicate that CBM development has resulted in increased TDS loading in the Study Area, the results of continued monitoring should be assessed for any future effects. The USGS is also currently working on a regional model to assess potential future water quality impacts, if any, of CBM development in Utah (Hunt 2003). Details of this study were not available at the time of this report.

Overall, the analysis of point source data revealed that the current impact of point source TDS on the WCRW streams is relatively minor (see additional discussion in Section 6.0).

4.2 Non-point Sources

While there are potential non-point source loadings of TDS from industrial and municipal sources, as discussed above, they are generally insignificant relative to the other non-point sources of TDS concentrations in the watershed. The most significant TDS loading are due to surface and sub-surface movement of water over the Mancos Shale geologic feature present in the area. Mancos Shale formations, which are known to be highly saline and soluble, dominate the middle portion of the WCRW, where irrigation is also ubiquitous. Ground water flows through the Mancos Shale and surface runoff over soils derived from Mancos Shale have been reported as resulting in substantial dissolution of salts (Apodaca 1998, Evangelou et al. 1984, Laronne 1977) and are the primary avenues by which TDS loadings are increased in the WCRW. Water quality data are shown in Appendix B. Specific types of non-point sources fore each of the listed impaired stream segments are summarized in Appendix A.

A previous water quality monitoring project (DEQ 2000) has determined that irrigation return flows, canal seepage, and stock pond seepage constitute a significant source of TDS in the WCRW. Nearly 400 miles of stream segments in the WCRW have been designated as non-supporting or partially supporting their beneficial use due to high TDS caused by agricultural activities. The BOR (2001) estimates that irrigation and other agricultural activities in the Price and San Rafael river sub-watersheds alone results in a salt loading of approximately 258,000 tons per year

Irrigation and associated canal seepage are the largest contributors of TDS in the WCRW. TDS loading associated with irrigation can occur from surface flow and from subsurface movement of return flows. Overland flow caused by over-irrigation can transport salts, as well as sediment, from the soil surface directly to streams. Salt has accumulated on the soil surface in many areas in the WCRW due to the dissolution of salts from the soil and subsurface materials. Below-ground irrigation return flows may eventually enter the groundwater and return to the stream. Data from stream gauges below irrigation areas in all sub-watersheds show significant increases in TDS loadings compared to data from gauges above irrigation areas. Increased TDS concentrations caused by irrigation return flows continue to degrade water quality as the water moves downstream and picks up increasing amounts of salts.

Seepage of water from unlined canals and stock ponds is also a significant contributor to the loading of streams in the WCRW. The BOR and SCS (1993) estimates that canal seepage increases the TDS load by 67.16 tons per mile of canal.

Runoff events are also a significant source of the total salt load in the WCRW. Previous studies have estimated that 21 percent of the salt load in the Price River and 14 percent of the salt load in the San Rafael River are related to runoff events caused by intense precipitation during thunderstorms (BOR 2001). Similar loading has been also been estimated for Muddy Creek (BOR 1987). Additionally, overland flow of snowmelt on lower elevation sites located on saline formations can significantly increase salinity.

Surface runoff over soil derived from Mancos Shale can potentially increase TDS by transporting salt laden soil particles into nearby streams. The aridity of the WCRW results in a net upward movement of water, which deposits salts on the soil surface. These salts are susceptible to movement by surface runoff from natural precipitation events, snowmelt, and over-irrigation (Laronne 1977). Runoff can be exacerbated by disturbances to the soil surface, such as forestry activities, overgrazing and recreational activities.

Improper forestry related activities can increase TDS loading by removing vegetative cover and other protective surfaces, such as pebbles and gravel, as well as loosening the soil surface, all of which increase the erosion potential caused by overland flow. Additionally, roads built for timber extraction are susceptible to erosion, as are all unpaved roads in the watershed. Both the road surface and the steep embankments can be severely eroded by relatively minor storms. However, due to the forested portions of the watershed occurring outside of the Mancos Shale, these practices generally contribute relatively insignificant salt loads.

Livestock and wildlife grazing can result in surface disturbance or compaction, which can alter infiltration, surface cover, and streambank stability. These changes can increase TDS loading in adjacent streams. Infiltration rates decrease, and runoff increases, as livestock or wildlife ground trampling increases. Dadkuh and Gifford (1980) found that untrampled soils exhibit more than two times the infiltration rate as trampled soils. They also reported that by increasing the cover of grasses from 30 percent to 50 percent, sediment production was decreased by more than 50 percent. Streambank degradation caused by watering animals in readily accessible streamside areas can also result in increased sediment production, and accompanying TDS loadings, in the WCRW.

Recreational activities are another potential source of TDS in the WCRW. The loss of vegetative cover and the loosening of soil particles associated with the use of recreational vehicles results in increased erosion potential and possible TDS loading into nearby streams. Recreational activities can also damage or remove the protective cryptogamic crust, which then results in increased sedimentation and associated TDS loading (Belnap et al. 2001).

5.0 LOADING CALCULATIONS

The ultimate goal of a TMDL is the attainment of water quality standards for impaired waters. In order to meet the goal of the TMDL, the relationship between source loading and the loading capacity of the receiving water must be established were feasible and achievable. The loading capacity is the amount of a given pollutant that can be assimilated by a water body while still meeting the water quality standard for the water body. For this TMDL, the water quality criterion is 1,200 mg/L TDS.

This section describes the procedures used for determining the loading capacity and current TDS loading in the Price River, San Rafael River, and Muddy Creek watersheds. In conjunction with historical flow records, loading capacities were established for flows expected to occur in an average year in the Price River, San Rafael River, and Muddy Creek, as well as selected tributaries in these watersheds, for which target points were established. Existing loads, which were calculated from available monitoring data, were compared to loading capacities in order to evaluate critical conditions and calculate the necessary load reductions.

Each of the established target sites in the WCRW has a TMDL of TDS that can be carried before the TDS criterion is exceeded. This TMDL is equivalent to the loading capacity at each of the target sites, which is calculated by the following formula:

Flow (cfs) x TDS WQ Criterion (1,200 mg/L) x 2.66xE-6 (Conversion Factor) = Load Capacity (tons/day)

This same formula is used to calculate existing loads by substituting measured TDS concentrations at respective flows for the TDS water quality criterion.

Critical conditions represent the condition or conditions under which the loading capacity of a target site is exceeded and violation of TDS criterion occurs. These critical conditions can be dependent on environmental and other watershed factors, such as rainfall events when TDS loading to surface waters occurs in surface runoff to the Study Area streams, as well as watershed activities, such as irrigation that can result in TDS loading through surface and ground water return flows. Critical conditions in the Study Area are difficult to identify because of the dynamic combination of hydrology and loading conditions. Loading times that have the greatest impact on water quality conditions are difficult to distinguish, because of lags created by ground water flows, surface water diversions and other factors such as irrigation rates.

As discussed in Section 3.5, violations of the TDS water quality criterion occur during all months of the year at target sites in all three Study Area watersheds. As described in the following sections, based on the available water quality data, the TMDL water quality criterion is violated throughout the entire year and at all expected normal flow conditions throughout the watersheds. Therefore, critical conditions in each of the three watersheds exist at all flow conditions, and the TMDLs will be based on flow conditions and not specific seasonal periods. Establishing a TMDL for TDS under all critical flow conditions ensures that the TDS water quality criterion is met under all conditions.

5.1 Price River Watershed

As previously discussed, STORET monitoring stations 493239 (Price River above WWTP in Wellington) and 493165 (Price River at Woodside) were designated as target sites in the Price River watershed and assessed for temporal and spatial variations in flow. The daily stream flows measured at these monitoring stations were arranged in order of magnitude and divided into flow tiers. Each flow tier represents a range of measured flows, the highest measured flow within the range assigned a percentage (e.g., 10 percent, 20 percent) that reflects the chance of any measured stream flow being less than or equal to it. For example, higher measured flow (e.g., 90 cfs) would have a lower (e.g. 10 percent) chance of criterion exceedance while a lower flow (e.g., 10 cfs) would have a greater chance of exceedance. To evaluate the critical flow conditions at each target site, the maximum load capacity for each flow tier was calculated based on the highest measured flow within the tier range of flows and this load capacity compared with existing loads (minimum, maximum, average) calculated from the data. These results are shown in Tables 5-1 (monitoring station 493239) and 5-2 (monitoring station 493165). Plots of calculated loading capacity at each flow tier versus *average* existing load calculated from the data are shown for each monitoring station in Figures 5-1 and 5-2, respectively.

As shown in Table 5-1, maximum TDS loads for all but the 10 percent and 20 percent percentile groups exceeded the allowable load capacities for each percentile group. The plot of average existing load versus calculated loading capacity (Figure 5-1) is consistent with the water quality assessment results presented in Section 3.4.1, which show that, on average, the TDS water quality standard at this monitoring station is exceeded throughout the entire year, except during higher flow periods in the summer (see Figure 3-2). The results for monitoring station 493165 show that loading capacities are exceeded and critical conditions exist throughout the entire range of flow tiers (Table 5-2), although average existing loads do not exceed loading capacities at higher flow tiers (Figure 5-2).

Table 5-1 Loading Statistics for Station 493239, Price River Watershed (Map 10, Price River above Price WWTP at Wellington bridge)

Flow Exceedances	Average Flow (cfs)[1]	Number of Loads[2]	Water Quality Violations[3]	Existing Load (tons/day)[4]			Load Capacity (tons/day)[5]
				Minimum	Maximum	Average	
0% - 10%	360	2	0	332	767	550	1,163
10% - 20%	100	3	0	114	299	178	323
20% - 30%	70	2	1	93	295	194	227
30% - 40%	45	3	1	72	242	144	146
40% - 50%	27	2	2	138	177	152	87
50% - 60%	19	3	3	121	141	131	61
60% - 70%	17	3	3	74	109	90	55
70% - 80%	14	2	2	96	116	106	47
80% - 90%	9	3	3	43	67	58	29
90% - 100%	5	2	2	25	41	33	15

[1] Flow values shown represent the highest measured flow within the respective flow tier over the period of 1/1990-12/2001.
[2] Equals the total number of available measurements (flow and TDS) within each flow tier from which loads were calculated (Appendix B).
[3] Number of times that the measured TDS concentrations exceeded 1,200 mg/L.
[4] Load (tons/day)= measured flow (cfs) x measured TDS concentration x 2.66xE-6 (Conversion Factor). Data is shown in Appendix B.
[5] Load capacity calculated as highest measured flow in each flow tier x TDS criterion of 1,200 mg/L x 2.66xE-6 (Conversion Factor).

Table 5-2 Loading Statistics for Station 493165, Price River Watershed (Map 10, Price River near Woodside at US 6 crossing)

Flow Exceedances	Average Flow (cfs)[1]	Number of Loads[2]	Water Quality Violations[3]	Existing Load (tons/day)[4]			Load Capacity (tons/day)[5]
				Minimum	Maximum	Average	
0% - 10%	236	5	2	471	1,612	826	763
10% - 20%	132	6	4	211	2,784	574	425
20% - 30%	72	6	6	255	513	361	232
30% - 40%	55	5	4	187	480	290	177
40% - 50%	50	6	5	74	358	262	161
50% - 60%	43	5	5	251	420	329	138
60% - 70%	36	6	6	187	279	220	117
70% - 80%	26	6	5	45	221	150	84
80% - 90%	20	5	5	115	188	145	63
90% - 100%	11	5	4	20	122	70	35

[1] Flow values shown represent the highest measured flow within the respective flow tier over the period of 1/1990-12/2001.
[2] Equals the total number of available measurements (flow and TDS) within each flow tier from which loads were calculated (Appendix B).
[3] Number of times that the measured TDS concentrations exceeded 1,200 mg/L.
[4] Load (tons/day)= measured flow (cfs) x measured TDS concentration x 2.66xE-6 (Conversion Factor). Data is shown in Appendix B.
[5] Load capacity calculated as highest measured flow in each flow tier x TDS criterion of 1,200 mg/L x 2.66xE-6 (Conversion Factor).

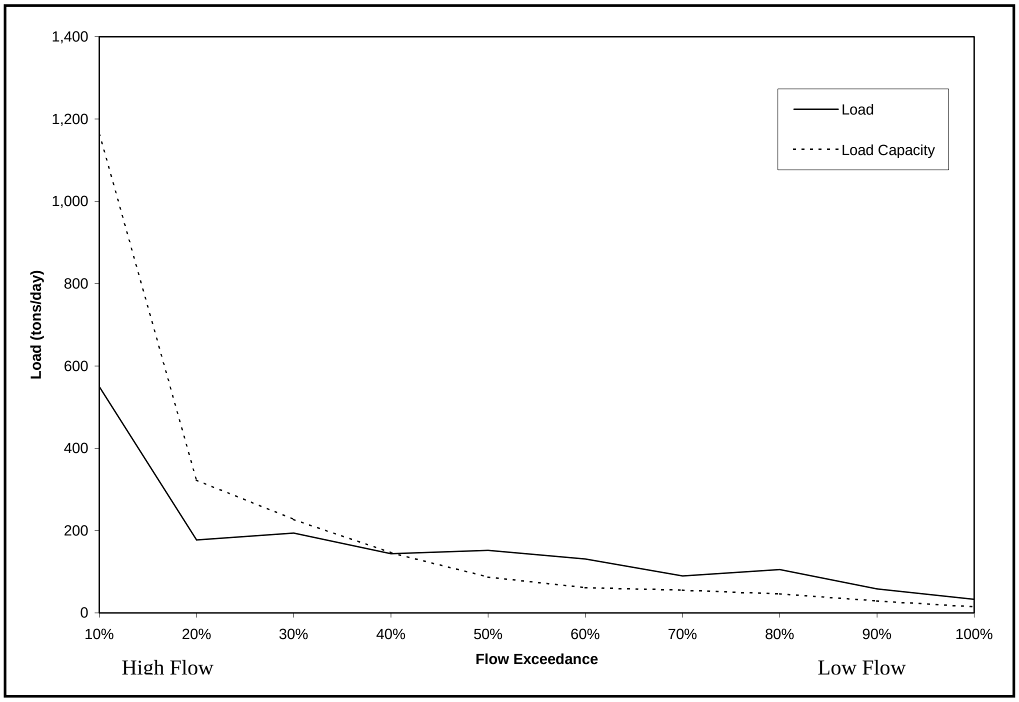

Figure 5-1 Existing TDS Loading by Flow for Station 493239 (Map 10, Price River above Price WWTP at Wellington Bridge)

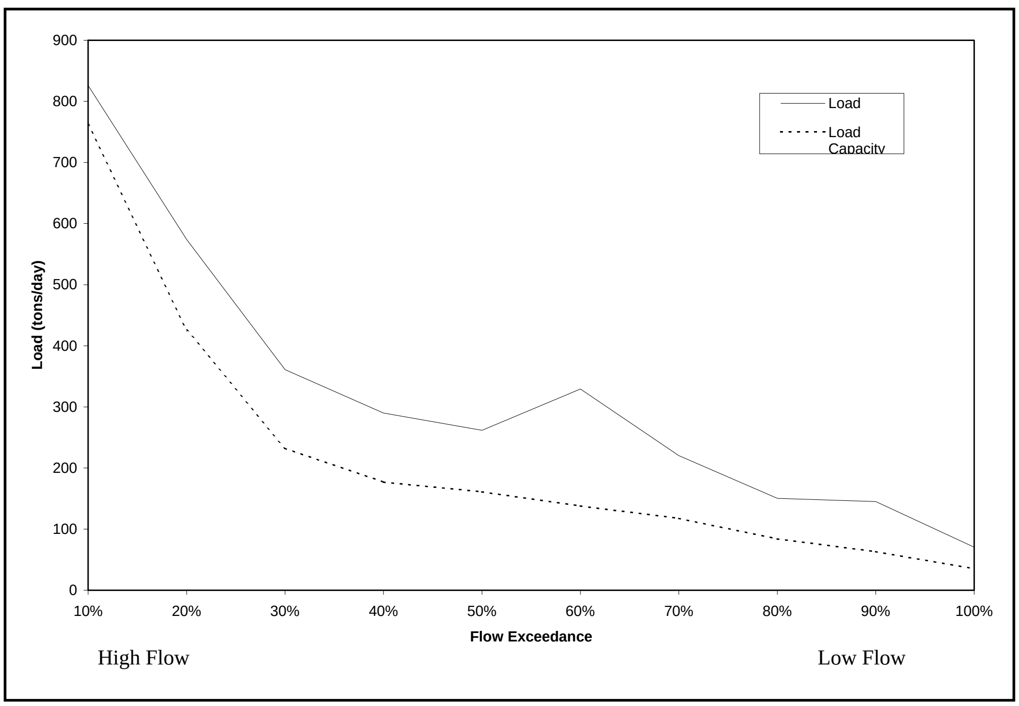

Figure 5-2 Existing TDS Loading by Flow for Station 493165 (Map 10, Price River near Woodside at US 6 Crossing)

5.2 San Rafael Watershed

Results of the analyses of loading capacities, existing loads, and critical conditions for target sites/monitoring stations EWCD-03 (Huntington Creek lower), EWCD-07 (Cottonwood Creek lower), EWCD-09 (Rock Canyon Creek lower), EWCD-11 (Ferron Creek lower), and STORET monitoring station 493029 (San Rafael at U24 crossing) in the San Rafael watershed are shown in Tables 5-3 through 5-7, and Figures 5-3 through 5-7, respectively. The results show that loading capacities are exceeded and critical conditions exist throughout the entire range of flow tiers at each of these monitoring stations (Tables 5-3 through 5-7), although average existing loads do not exceed loading capacities at higher flow tiers at monitoring stations EWCD-07, EWCD-11, and STORET monitoring station 493029 (Figures 5-4, 5-6, and 5-7, respectively).

Table 5-3 Loading Statistics for Station EWCD-03, Huntington Creek Watershed (Map 11, lower Huntington Creek)

Flow Exceedances	Average Flow (cfs)[1]	Number of Loads[2]	Water Quality Violations[3]	Existing Load (tons/day)[4]			Load Capacity (tons/day)[5]
				Minimum	Maximum	Average	
0% - 10%	107	14	7	142	741	371	344
10% - 20%	50	15	14	181	602	281	163
20% - 30%	24	14	14	123	235	171	77
30% - 40%	17	14	14	81	223	129	53
40% - 50%	12	15	15	73	160	122	40
50% - 60%	9	14	14	65	141	93	29
60% - 70%	7	15	15	51	125	80	24
70% - 80%	6	14	14	45	88	65	18
80% - 90%	4	14	14	24	61	42	13
90% - 100%	1	14	14	1	26	13	4

[1] Flow values shown represent the highest measured flow within the respective flow tier over the period of 1/1990-12/2001.
[2] Equals the total number of available measurements (flow and TDS) within each flow tier from which loads were calculated (Appendix B).
[3] Number of times that the measured TDS concentrations exceeded 1,200 mg/L.
[4] Load (tons/day)= measured flow (cfs) x measured TDS concentration x 2.66xE-6 (Conversion Factor). Data is shown in Appendix B.
[5] Load capacity calculated as highest measured flow in each flow tier x TDS criterion of 1,200 mg/L x 2.66xE-6 (Conversion Factor).

Table 5-4 Loading Statistics for Station EWCD-07, Cottonwood Creek Watershed (Map 11, lower Cottonwood Creek)

Flow Exceedances	Average Flow (cfs)[1]	Number of Loads[2]	Water Quality Violations[3]	Existing Load (tons/day)[4]			Load Capacity (tons/day)[5]
				Minimum	Maximum	Average	
0% - 10%	175	14	6	173	882	332	566
10% - 20%	37	15	13	112	223	169	121
20% - 30%	27	14	13	90	223	149	89
30% - 40%	22	15	15	83	230	135	72
40% - 50%	20	14	14	79	156	117	64
50% - 60%	18	15	15	73	130	109	58
60% - 70%	15	14	14	73	125	100	50
70% - 80%	13	15	15	69	125	94	42
80% - 90%	9	14	13	18	136	70	29
90% - 100%	4	14	14	11	70	41	13

[1] Flow values shown represent the highest measured flow within the respective flow tier over the period of 1/1990-12/2001.
[2] Equals the total number of available measurements (flow and TDS) within each flow tier from which loads were calculated (Appendix B).
[3] Number of times that the measured TDS concentrations exceeded 1,200 mg/L.
[4] Load (tons/day)= measured flow (cfs) x measured TDS concentration x 2.66xE-6 (Conversion Factor). Data is shown in Appendix B.
[5] Load capacity calculated as highest measured flow in each flow tier x TDS criterion of 1,200 mg/L x 2.66xE-6 (Conversion Factor).

Table 5-5 Loading Statistics for Station EWCD-09, Rock Canyon Creek Watershed (Map 11, lower Rock Canyon Creek)

Flow Exceedances	Average Flow (cfs)[1]	Number of Loads[2]	Water Quality Violations[3]	Existing Load (tons/day)[4]			Load Capacity (tons/day)[5]
				Minimum	Maximum	Average	
0% - 10%	27	13	13	99	208	142	89
10% - 20%	19	14	14	82	267	120	61
20% - 30%	13	14	14	67	177	107	41
30% - 40%	10	13	13	51	138	75	33
40% - 50%	8	14	14	51	122	72	26
50% - 60%	6	13	12	13	88	61	20
60% - 70%	5	14	14	39	92	59	17
70% - 80%	4	14	14	31	94	51	13
80% - 90%	3	13	13	32	54	41	10
90% - 100%	2	13	13	15	38	24	6

[1] Flow values shown represent the highest measured flow within the respective flow tier over the period of 1/1990-12/2001.
[2] Equals the total number of available measurements (flow and TDS) within each flow tier from which loads were calculated (Appendix B).
[3] Number of times that the measured TDS concentrations exceeded 1,200 mg/L.
[4] Load (tons/day)= measured flow (cfs) x measured TDS concentration x 2.66xE-6 (Conversion Factor). Data is shown in Appendix B.
[5] Load capacity calculated as highest measured flow in each flow tier x TDS criterion of 1,200 mg/L x 2.66xE-6 (Conversion Factor).

Table 5-6 Loading Statistics for Station EWCD-11, Ferron Creek Watershed (Map 11, lower Ferron Creek)

Flow Exceedances	Average Flow (cfs)[1]	Number of Loads[2]	Water Quality Violations[3]	Existing Load (tons/day)[4]			Load Capacity (tons/day)[5]
				Minimum	Maximum	Average	
0% - 10%	120	14	4	95	522	225	386
10% - 20%	20	15	15	80	175	109	66
20% - 30%	12	14	14	56	114	83	40
30% - 40%	10	14	14	45	83	63	32
40% - 50%	7	15	15	40	139	60	23
50% - 60%	5	14	14	28	54	42	18
60% - 70%	4	15	15	22	47	33	14
70% - 80%	4	14	14	26	41	30	11
80% - 90%	2	14	14	11	30	20	7
90% - 100%	1	14	14	1	20	7	2

[1] Flow values shown represent the highest measured flow within the respective flow tier over the period of 1/1990-12/2001.
[2] Equals the total number of available measurements (flow and TDS) within each flow tier from which loads were calculated (Appendix B).
[3] Number of times that the measured TDS concentrations exceeded 1,200 mg/L.
[4] Load (tons/day)= measured flow (cfs) x measured TDS concentration x 2.66xE-6 (Conversion Factor). Data is shown in Appendix B.
[5] Load capacity calculated as highest measured flow in each flow tier x TDS criterion of 1,200 mg/L x 2.66xE-6 (Conversion Factor).

Table 5-7 Loading Statistics for Station 493029, Lower San Rafael River Watershed (Map 11, San Rafael River at US 24 crossing)

Flow Exceedances	Average Flow (cfs)[1]	Number of Loads[2]	Water Quality Violations[3]	Existing Load (tons/day)[4]			Load Capacity (tons/day)[5]
				Minimum	Maximum	Average	
0% - 10%	291	6	1	479	1,067	715	939
10% - 20%	91	6	6	425	474	457	293
20% - 30%	51	6	6	204	500	333	165
30% - 40%	37	6	6	214	345	276	120
40% - 50%	29	6	6	202	230	211	93
50% - 60%	25	6	6	171	230	204	80
60% - 70%	17	6	6	106	184	148	56
70% - 80%	14	7	7	85	145	115	46
80% - 90%	6	6	6	25	103	67	21
90% - 100%	2	5	5	14	36	21	6

[1] Flow values shown represent the highest measured flow within the respective flow tier over the period of 1/1990-12/2001.
[2] Equals the total number of available measurements (flow and TDS) within each flow tier from which loads were calculated (Appendix B).
[3] Number of times that the measured TDS concentrations exceeded 1,200 mg/L.
[4] Load (tons/day)= measured flow (cfs) x measured TDS concentration x 2.66xE-6 (Conversion Factor). Data is shown in Appendix B.
[5] Load capacity calculated as highest measured flow in each flow tier x TDS criterion of 1,200 mg/L x 2.66xE-6 (Conversion Factor).

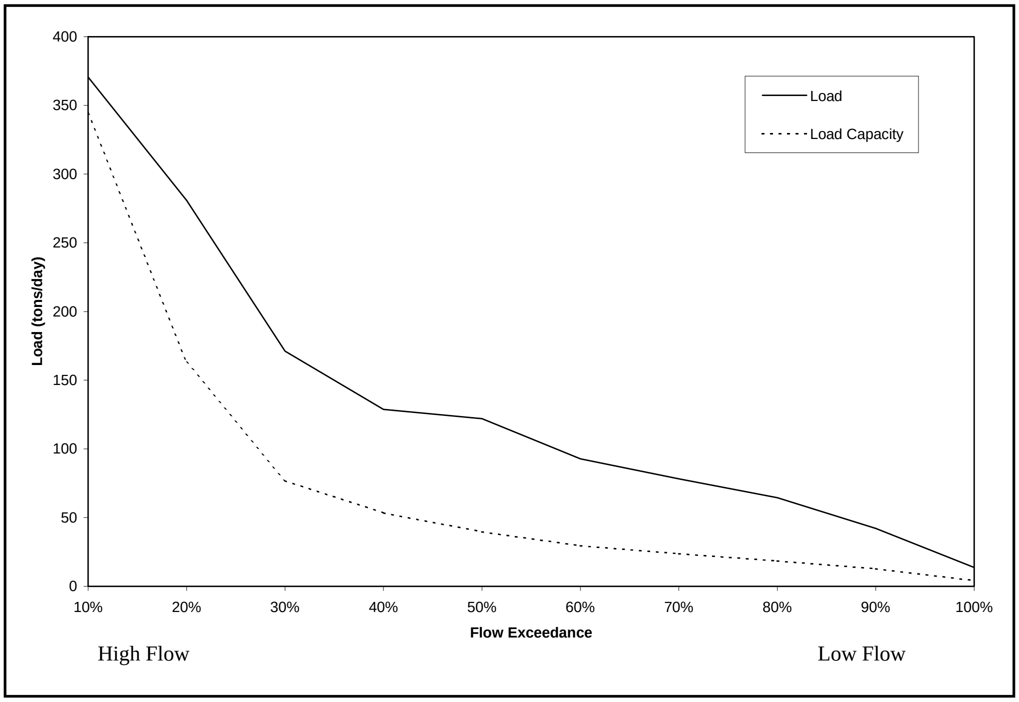

Figure 5-3 **Existing TDS Loading by Flow for Station EWCD-03 (Map 11, Lower Huntington Creek)**

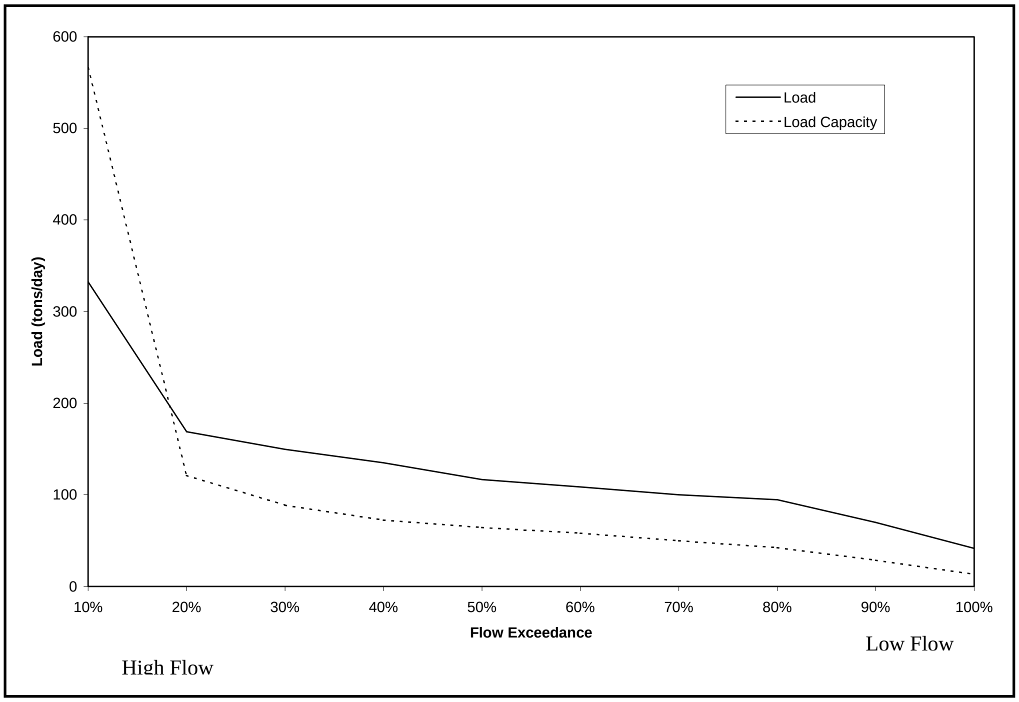

Figure 5-4 **Existing TDS Loading by Flow for Station EWCD-07 (Map 11, Lower Cottonwood Creek)**

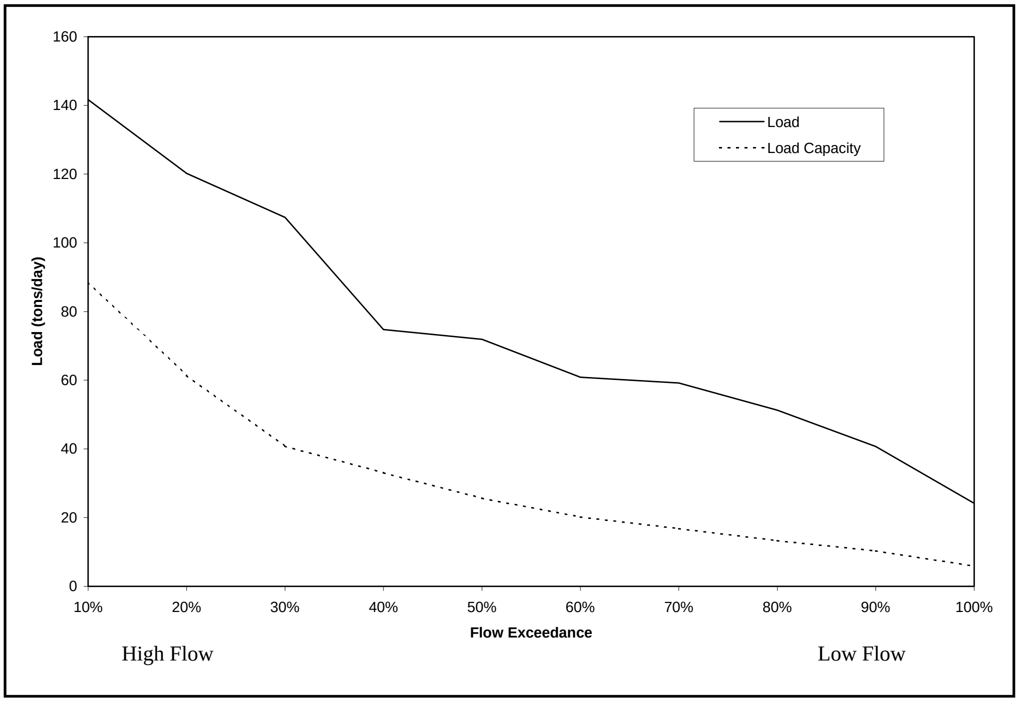

Figure 5-5 Existing TDS Loading by Flow for Station EWCD-09 (Map 11, Lower Rock Canyon Creek)

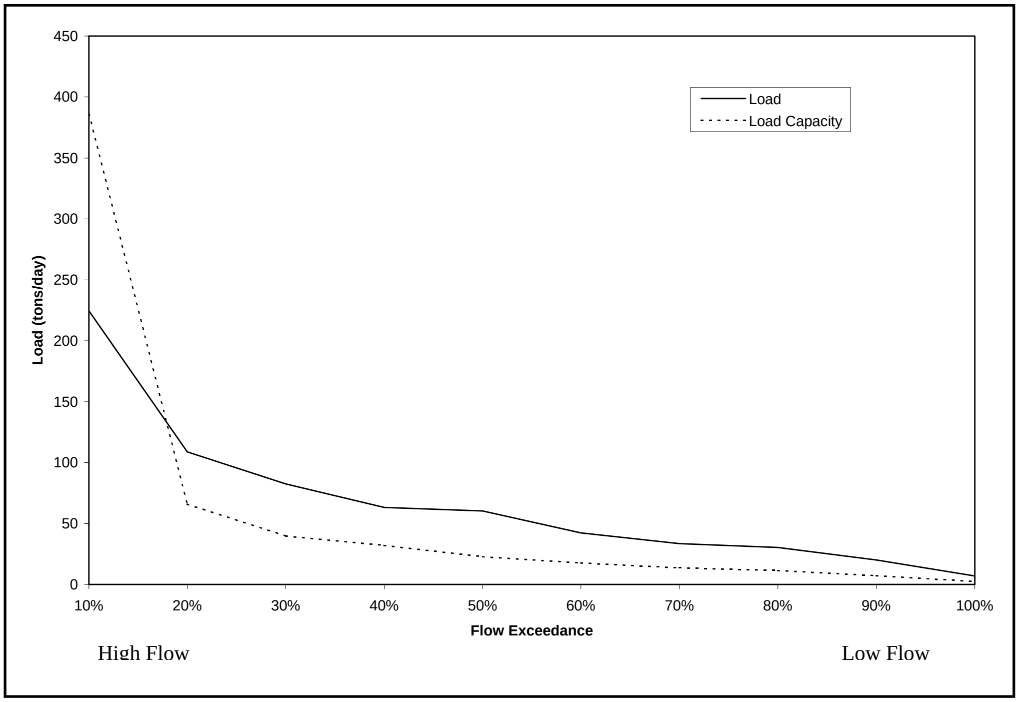

Figure 5-6 Existing TDS Loading by Flow for Station EWCD-11 (Map 11, Lower Ferron Creek)

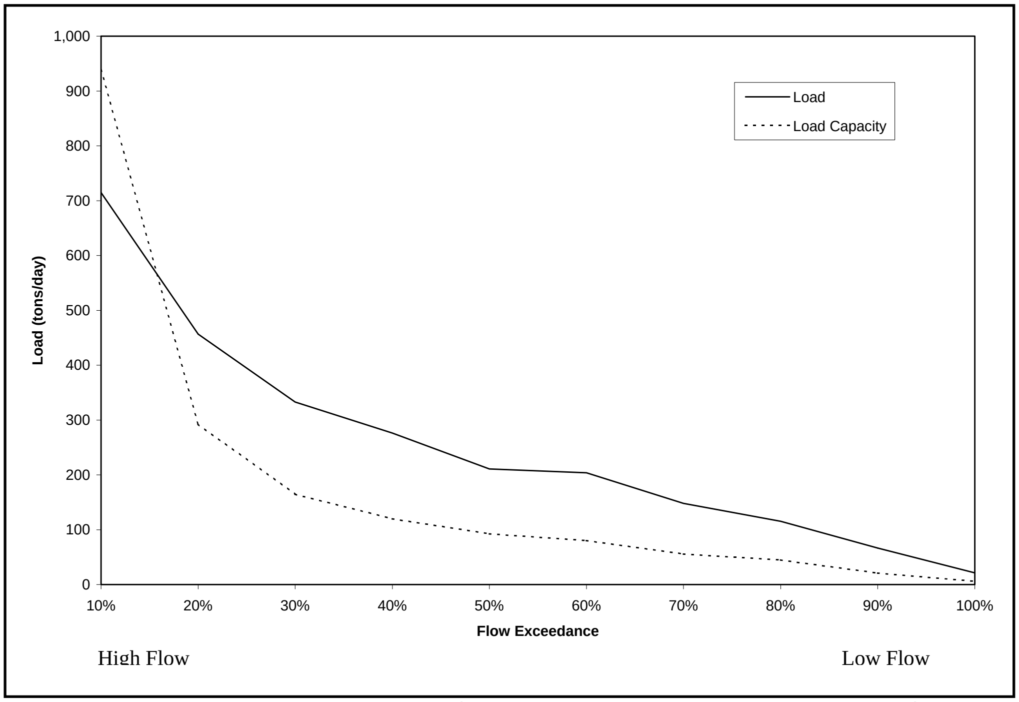

Figure 5-7 Existing TDS Loading by Flow for Station 493029 (Map 11, San Rafael River at US 24 crossing)

5.3 Muddy Creek

Results of the analyses of loading capacities, existing loads, and critical conditions for target sites/monitoring station EWCD-14 (Muddy Creek lower) and STORET monitoring station 495500 (Muddy Creek at old U24 crossing) in the Muddy Creek watershed are shown in Tables 5-8 and 5-9, and Figures 5-8 and 5-9, respectively. The results show that loading capacities are exceeded and critical conditions exist throughout the entire range of flow tiers at each of these monitoring stations (Tables 5-8 and 5-9), although average existing loads do not exceed loading capacities at higher flow tiers at monitoring station EWCD-14 (Figure 5-8).

Table 5-8 Loading Statistics for Station EWCD-14 Muddy Creek Watershed (Map 12, lower Muddy Creek)

Flow Exceedances	Average Flow (cfs)[1]	Number of Loads[2]	Water Quality Violations[3]	Existing Load (tons/day)[4]			Load Capacity (tons/day)[5]
				Minimum	Maximum	Average	
0% - 10%	79	14	3	82	414	164	256
10% - 20%	30	14	6	43	115	88	97
20% - 30%	17	15	11	33	159	69	56
30% - 40%	11	14	11	30	66	46	36
40% - 50%	9	14	11	25	56	40	31
50% - 60%	8	15	14	28	53	37	26
60% - 70%	5	14	14	18	36	25	16
70% - 80%	3	14	14	13	33	20	11
80% - 90%	2	14	14	7	25	12	6
90% - 100%	1	14	13	2	9	6	3

[1] Flow values shown represent the highest measured flow within the respective flow tier over the period of 1/1990-12/2001.
[2] Equals the total number of available measurements (flow and TDS) within each flow tier from which loads were calculated (Appendix B).
[3] Number of times that the measured TDS concentrations exceeded 1,200 mg/L.
[4] Load (tons/day)= measured flow (cfs) x measured TDS concentration x 2.66xE-6 (Conversion Factor). Data is shown in Appendix B.
[5] Load capacity calculated as highest measured flow in each flow tier x TDS criterion of 1,200 mg/L x 2.66xE-6 (Conversion Factor).

Table 5-9 Loading Statistics for Station 495500, Muddy Creek Watershed (Map 12, Muddy Creek at old US 24 crossing)

Flow Exceedances	Average Flow (cfs)[1]	Number of Loads[2]	Water Quality Violations[3]	Existing Load (tons/day)[4]			Load Capacity (tons/day)[5]
				Minimum	Maximum	Average	
0% - 10%	159	7	7	334	5,151	1,402	514
10% - 20%	45	7	6	87	452	259	145
20% - 30%	31	7	5	86	287	185	102
30% - 40%	24	7	6	65	302	177	76
40% - 50%	18	7	7	106	155	133	58
50% - 60%	12	7	7	71	158	119	38
60% - 70%	7	8	8	47	105	74	21
70% - 80%	5	7	7	44	83	55	15
80% - 90%	2	7	7	23	54	34	8
90% - 100%	1	6	6	0	15	7	2

[1] Flow values shown represent the highest measured flow within the respective flow tier over the period of 1/1990-12/2001.
[2] Equals the total number of available measurements (flow and TDS) within each flow tier from which loads were calculated (Appendix B).
[3] Number of times that the measured TDS concentrations exceeded 1,200 mg/L.
[4] Load (tons/day)= measured flow (cfs) x measured TDS concentration x 2.66xE-6 (Conversion Factor). Data is shown in Appendix B.
[5] Load capacity calculated as highest measured flow in each flow tier x TDS criterion of 1,200 mg/L x 2.66xE-6 (Conversion Factor).

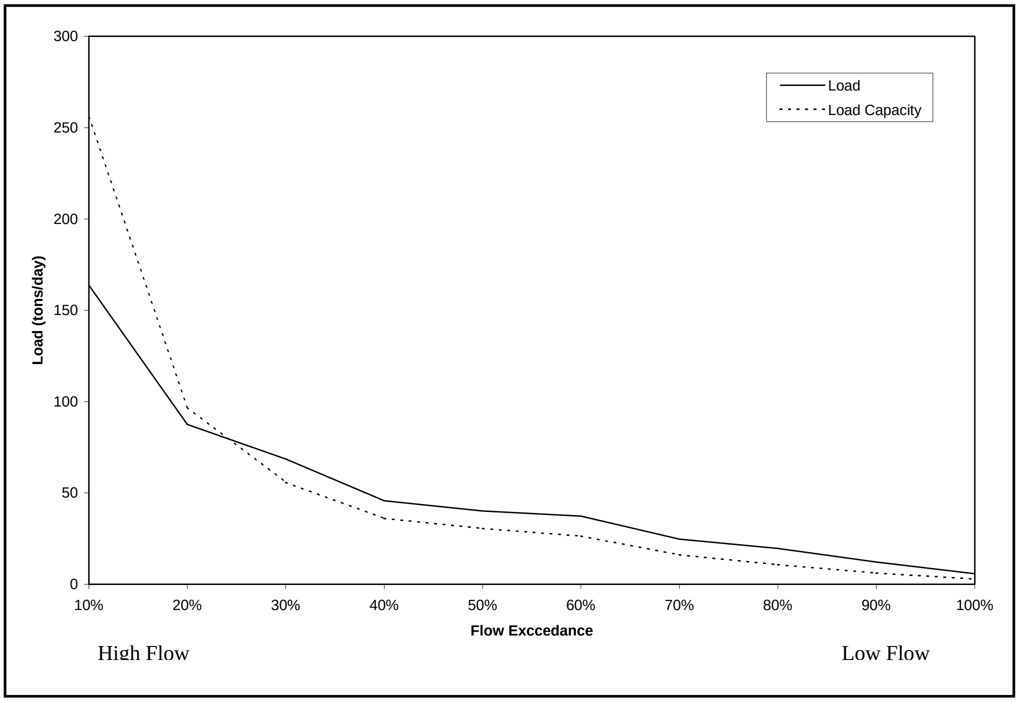

Figure 5-8 Existing TDS Loading by Flow for Station EWCD-14 (Map 12, Lower Muddy Creek)

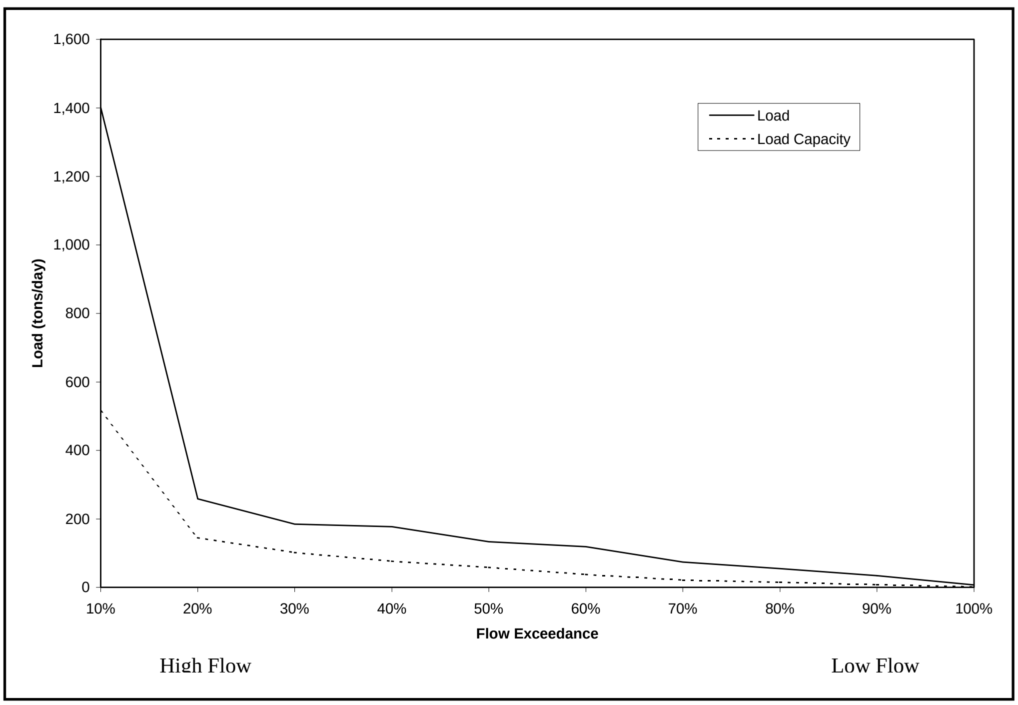

Figure 5-9 Existing TDS Loading by Flow for Station 495500 (Map 12, Muddy Creek at old US 24 crossing)

6.0 TMDL AND LOAD ALLOCATION

6.1 Description of TMDL Allocation

A TMDL is composed of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for non-point sources and natural background loading (which is naturally occurring and cannot be controlled), and a margin of safety (MOS) that either implicitly or explicitly accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving streams. A TMDL is denoted by the equation:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS.$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving stream while still achieving water quality standards. For some pollutants, TMDLs are expressed as a mass-loading basis (e.g., pounds or kilograms per day). In some cases, a TMDL is expressed as another appropriate measure that is the relevant expression for the reduction of loadings of the specific pollutant needed to meet water quality standards or goals. The TMDLs for TDS for the Price River, San Rafael River, and Muddy Creek watershed are expressed on a mass-loading basis (tons/day) and represent the loading capacity of the watershed streams to assimilate TDS load and achieve the TDS water quality standard.

6.2 Margin of Safety

The MOS is a required part of the TMDL development process. There are two basic methods for incorporating the MOS:

- Implicitly incorporate the MOS using conservative model assumptions to develop allocations
- Explicitly specify a portion of the total TMDL (stream loading capacity) as the MOS.

For the Price River, San Rafael River, and Muddy Creek TMDLs, the MOS was calculated as 5 percent of stream loading capacity.

6.3 TMDL Allocations

The TMDLs and load allocations for the Price River, San Rafael River, and Muddy Creek watersheds were developed based on flow and water quality data over an 11-year period of record from 1990 to 2001. The average annual loading capacity/TMDL at each target site was calculated as the product of the average annual flow at the target site, the TDS standard criterion of 1,200 mg/L, and a conversion factor to express the average annual loading capacity/TMDL in tons/year TDS. The difference between the

TMDL and the existing average annual TDS load at each target (calculated using water quality and flow data at each target site over the 11-year period of record) plus the MOS represents the reduction in TDS loading required to meet the TMDL at that site. This reduction in TDS loading was, in turn, used to determine the allocation in TDS loading from non-point sources under the TMDLs.

The existing average annual TDS load at each target site is comprised of TDS loads from both point and non-point sources. The average annual point-source TDS load at each target site was calculated from discharge monitoring report data from permitted point-source dischargers located above the site (see Section 4, Tables 4-1 and 4-2). The average annual non-point source TDS load at each target site was calculated as the difference between the existing average annual TDS load and average annual point-source load. As shown in Tables 6-2 through 6-10, existing TDS load from point sources is generally much less than the non-point source load. At the lowest target site in each watershed, the point source load is less than 5% of the total existing load (Tables 6-3, 6-8, and 6-10). The existing point source load at all target sites is less than 10% of the existing load. This TMDL proposes to establish point source permits as the permits come open for review. The proposed limits listed in Table 6-1 will come into effect at that time. The resulting WLAs based on the limits listed in Table 6-1 are also listed in Tables 6-2 through 6-10. The reduction in TDS load required to meet the average annual loading capacity/TMDL at each target site was applied to non-point source loading to arrive at load allocations under the TMDLs, as based on the proposed new WLAs.

Tables 6-2 through 6-10 summarize the existing average annual point- and non-point source loads, loading capacity, reduction in TDS load to meet the loading capacity, and the waste load, load allocations, and MOS under the TMDL for each target site in the Price River, San Rafael River, and Muddy Creek watersheds.

Table 6-1 Proposed New Permit Limits for TDS for the Existing Point Sources in WCRW.

Permittee[1] Name/Permit Number	Permit Limit[1] (mg/L)	Annual Load Limit[2] (tons/year)	Notes
Ark Land Company (UT0025453)	565	30	Concentration-based limit; load calculated using design flow
Canyon Fuel - SUFCO (UT0022918)		10,044	Annual load limit= design flow x 1,200 mg/L
Castle Valley Special SSD (UT0023663)		1,278	Facility has 2 years to conduct inflow/infiltration study[3]
Castle Valley SSD – Huntington (UT0021296)		730	Facility has 2 years to conduct inflow/infiltration study
Ferron Lagoons- Ferron (UT0020052)		986	Facility has 2 years to conduct inflow/infiltration study
Consolidation Coal –Emery (UT0022616)		1,104	Annual load limit= design flow x 1,200 mg/L
Co-Op Mining Company (UT040006)	880	670	Concentration-based limit; load calculated using design flow
Hiawatha Coal Company (UT0023094)	981	941	Concentration-based limit; load calculated using design flow
Interwest Mining Co- Des Be Dov (UTG040022)			No UPDES permit required [4]
Lodestar Energy – Horizon (UTG040019)	519	1,035	Concentration-based limit; load calculated using design flow
Pacific – Carbon Plant (UT0000094)		552	Annual load limit= design flow x 1,200 mg/L
Pacificorp – Trail Mountain (UTG040003)		138	Concentration-based limit; load calculated using design flow
Price River Water Imp. Dist (UT0021814)		7,304	Facility has 2 years to conduct inflow/infiltration study
Talon Resources Inc. (UT0025399)		89	Annual load limit= design flow x 1,200 mg/L

1. For concentration based discharge permit limit calculation purposes, if there were more that 20 TDS data points available, the 95th percentile of that data set was used; otherwise the average of data points, less than 20 were taken, plus two standard deviations.
2. The annual load limit is the waste load allocation for each permitted point source
3. Facilities will have up to two years to conduct an (I&I) Inflow/Infiltration study to determine the extent of I&I from ground water into their collection systems, followed by a project to repair or replace defective sewer piping.
4. This mining facility does not have a mine water discharge (dry mine) thus is would not be required to have a UPDES Discharge Permit. The facility has constructed holding ponds designed to receive and hold a 10 year 24 hour storm event. The facility discharges from the storm water containment about once every three years. This is generally done to for preventative maintenance measures

6.3.1 Existing Conditions

The existing condition represents TDS loadings in the Price River, San Rafael River, and Muddy Creek watersheds calculated using existing monitoring data. As discussed in Section 5, existing loads were calculated for days that had recorded flow and TDS concentrations. The average annual TDS loadings are summarized in Tables 6-2 through 6-10. These tables also list the estimated existing TDS loads from specific point sources and the proposed waste load allocations for these existing point sources. The derivation of these values is summarized in Table 6-1. Permit limits were set using three methods: 1) for current discharges that are less than the 1,200 mg/L, the 95th percentile TDS concentrations was set as the permit limit; 2) for discharges that are at or slightly above the 1,200 mg/l criteria, a total annual load of the design flow x 1,200 mg/L is used, and 3) for discharges that occur where there is sufficient mixing capacity, the permit limit is established to prevent exceedance of the 1,200 mg/L criteria..

The estimated allocation of the non-point load to different sources (e.g., canal seepage, irrigation return flows, erosion) for each watershed is provided in the Project Implementation Plan (Appendix A). For the Price River-Wellington (Storet 49329), the table is shown for the average annual period (Table 6-2a) and for the defined critical condition (Table 6-2b), which is for the 40-100 percent flow exceedance (Table 5-1).

Table 6-2a Summary of Average Annual TDS Load and TMDL Load Allocation for the Price River Watershed from Coal Creek to Carbon Canal Diversion (based on UTDEQ STORET Station 493239- Price River above Price WWTP at Wellington Bridge)

Source	Existing TDS Load (tons/year)	WLA[1] (tons/year)
Point Source		
NPDES UTG040019[a]	*258*	*1,035*
NPDES UT0023094[b]	*146*	*941*
NPDES UT0000094[c]	*146*	*552*
NPDES UT0025453[d]	*8*	*30*
NPDES UT0021814[e]	*2,190*	*7,304*
Total Point Source Load	2,748	9,862
Non-Point Source Load[2]	62,874	
Total Existing Load[3]	65,622	
Loading Capacity[4]	79,847	
Margin of Safety[5]	3,992	
Load Reduction Required to Meet Loading Capacity[6]	0	

Source	TMDL TDS Load Allocation[7] (tons/year)	% of Reduction in Existing Load to Achieve Allocation
Point Source	9,862	0%
Non-Point Source	65,994	0%
Margin of Safety	3,992	Not Applicable

Notes:
a. Lodestar Energy Inc. – Horizon, H.C. Box 370, Helper, UT. Data collected from 3/31/2000 – 12/31/2002.
b. Mine discharge. Hiawatha Coal Company, P.O. Box 1201, Huntington UT. Data collected from 8/31/2000 – 12/31/2002.
c. Power plant. Data collected from 12/31/2001 – 12/31/2002.
d. Ark Land Company. Data collected from 8/31/2002 – 11/30/2002. Due to high flow during the 8/31/2002 – 10/31/2002 period only the data from 11/30/2002 is used.
e. Price Waste Water Treatment Plant. Data collected from 1/31/2002 – 12/31/2002.
1. Waste load allocations (WLA) are discussed in Table 6-1
2. Non-point source load = total existing load – point source load
3. Total existing load calculated based on available flow and water chemistry data over 11-year period (1990 – 2001)
4. Loading capacity = average annual flow for period of 1/1990-12/2001 x 1,200 mg/L x conversion factor
5. Margin of safety = 5% of loading capacity
6. Load reduction = total existing load – (loading capacity - margin of safety)
7. Point source is listed from WLA. Non-point= loading capacity- WLA- margin of safety

Table 6-2b Summary of Average TDS Load and TMDL Load Allocation for critical conditions in the Price River Watershed from Coal Creek to Carbon Canal Diversion (based on UTDEQ STORET Station 493239- Price River above Price WWTP at Wellington Bridge)

Source	**TDS Load (tons/year)**	**WLA[1] (tons/year)**
Point Source		
NPDES UTG040019[a]	*258*	*1,035*
NPDES UT0023094[b]	*146*	*941*
NPDES UT0000094[c]	*146*	*552*
NPDES UT0025453[d]	*8*	*30*
NPDES UT0021814[e]	*2,190*	*7,304*
Total Point Source Load	2,748	9,862
Non-Point Source Load[2]	52,732	
Total Existing Load[3]	55,480	
Loading Capacity[4]	31,755	
Margin of Safety[5]	1,588	
Load Reduction Required to Meet Loading Capacity[6]	25,313	

Source	**TMDL TDS Load Allocation[7] (tons/year)**	**% of Reduction in Existing Load to Achieve Allocation**
Point Source	9,862	0%
Non-Point Source	20,305	61%
Margin of Safety	1,588	Not Applicable

Notes: a. Lodestar Energy Inc. – Horizon, H.C. Box 370, Helper, UT. Data collected from 3/31/2000 – 12/31/2002.
b. Mine discharge. Hiawatha Coal Company, P.O. Box 1201, Huntington UT. Data collected from 8/31/2000 – 12/31/2002.
c. Power plant. Data collected from 12/31/2001 – 12/31/2002.
d. Ark Land Company. Data collected from 8/31/2002 – 11/30/2002. Due to high flow during the 8/31/2002 – 10/31/2002 period only the data from 11/30/2002 is used.
e. Price Waste Water Treatment Plant. Data collected from 1/31/2002 – 12/31/2002.
1. Waste load allocations (WLA) are discussed in Table 6-1
2. Non-point source load = total existing load – point source load
3. Total existing load calculated based on available flow and water chemistry data over 11-year period (1990 – 2001)
4. Loading capacity = average annual flow for period of 1/1990-12/2001 x 1,200 mg/L x conversion factor
5. Margin of safety = 5% of loading capacity
6. Load reduction = total existing load – (loading capacity - margin of safety)
7. Point source is listed from WLA. Non-point= loading capacity- WLA- margin of safety

Table 6-3 Summary of Average Annual TDS Load and TMDL Load Allocation for the Price River Watershed from Confluence of Green River to Soldier Creek Confluence (based on UTDEQ STORET Station 493165- Price River near Woodside at US 6 Crossing)

Source	TDS Load (tons/year)	WLA[1] (tons/year)
Point Source		
NPDES UTG040019[a]	*258*	*1,035*
NPDES UT0023094[b]	*146*	*941*
NPDES UT0000094[c]	*146*	*552*
NPDES UT0025453[d]	*8*	*30*
NPDES UT0021814[e]	*2,190*	*7,304*
Total Point Source Load	2,748	9,862
Non-Point Source Load[2]	126,849	
Total Existing Load[3]	129,597	
Loading Capacity[4]	74,200	
Margin of Safety[5]	3,710	
Load Reduction Required to Meet Loading Capacity[6]	59,107	

Source	TMDL TDS Load Allocation[7] (tons/year)	% of Reduction in Existing Load to Achieve Allocation
Point Source	9,862	0%
Non-Point Source	60,628	52%
Margin of Safety	3,710	Not Applicable

Notes: a. Lodestar Energy Inc. – Horizon, H.C. Box 370, Helper, UT. Data collected from 3/31/2000 – 12/31/2002.
b. Mine discharge. Hiawatha Coal Company, P.O. Box 1201, Huntington UT. Data collected from 8/31/2000 – 12/31/2002.
c. Power plant. Data collected from 12/31/2001 – 12/31/2002.
d. Ark Land Company. Data collected from 8/31/2002 – 11/30/2002. Due to high flow during the 8/31/2002 – 10/31/2002 period only the data from 11/30/2002 is used.
e. Price Waste Water Treatment Plant. Data collected from 1/31/2002 – 12/31/2002.
1. Waste load allocations (WLA) are discussed in Table 6-1
2. Non-point source load = total existing load – point source load
3. Total existing load calculated based on available flow and water chemistry data over 11-year period (1990 – 2001)
4. Loading capacity = average annual flow for period of 1/1990-12/2001 x 1,200 mg/L x conversion factor
5. Margin of safety = 5% of loading capacity
6. Load reduction = total existing load – (loading capacity - margin of safety)
7. Point source is listed from WLA. Non-point= loading capacity- WLA- margin of safety

Table 6-4 Summary of Average Annual TDS Load and TMDL Load Allocation for the Huntington Creek Watershed from Confluence with Cottonwood Creek Upstream to USFS Boundary (based on EWCD-03- Lower Huntington Creek)

Source	TDS Load (tons/year)	WLA[1] (tons/year)
Point Source		
NPDES UTG040006[a]	*35*	*670*
NPDES UT0021296[b]	*0.001*	*730*
Total Point Source Load	35	1400
Non-Point Source Load[2]	58,504	
Total Existing Load[3]	58,539	
Loading Capacity[4]	27,776	
Margin of Safety[5]	1,389	
Load Reduction Required to Meet Loading Capacity[6]	32,152	

Source	TMDL TDS Load Allocation[7] (tons/year)	% of Reduction in Existing Load to Achieve Allocation
Point Source	1,400	0%
Non-Point Source	24,987	57%
Margin of Safety	1,389	Not Applicable

Notes: a. Co-Op Mining – Bear/Trail Mines. Data collected from 5/30/1998 – 12/31/2002.
b. Castle Valley SSD (Huntington). Data collected from 10/31/2002 – 12/31/2002.
1. Waste load allocations (WLA) are discussed in Table 6-1
2. Non-point source load = total existing load – point source load
3. Total existing load calculated based on available flow and water chemistry data over 11-year period (1990 – 2001)
4. Loading capacity = average annual flow for period of 1/1990-12/2001 x 1,200 mg/L x conversion factor
5. Margin of safety = 5% of loading capacity
6. Load reduction = total existing load – (loading capacity - margin of safety)
7. Point source is listed from WLA. Non-point= loading capacity- WLA- margin of safety

Table 6-5 Summary of Average Annual TDS Load and TMDL Load Allocation for the Cottonwood Creek Watershed from the Confluence of Huntington Creek to Highway 57 (based on EWCD-07- Lower Cottonwood Creek)

Source	TDS Load (tons/year)	WLA[1] (tons/year)
Point Source		
NPDES UTG040003[a]	*233*	*138*
NPDES UTG040022[b]	*0.0002*	*0*
NPDES UT0025399[c]	*3*	*89*
NPDES UT0023663[d]	*730*	*1278*
Total Point Source Load	966	1500
Non-Point Source Load[2]	67,041	
Total Existing Load[3]	68,007	
Loading Capacity[4]	39,940	
Margin of Safety[5]	1,997	
Load Reduction Required to Meet Loading Capacity[6]	30,064	

Source	TMDL TDS Load Allocation[7] (tons/year)	% of Reduction in Existing Load to Achieve Allocation
Point Source	1,500	0%
Non-Point Source	36,443	46%
Margin of Safety	1,997	Not Applicable

Notes: a. Pacificorp – Trail Mtn. Mine. Data collected from 1/31/1998 – 5/30/1998.
b. Interwest Mining CO-DES-BEE. Data collected from 10/31/2001 – 12/31/2001.
c. Talon Resources Inc. Data collected from 6/30/2002 – 12/31/2002.
d. Castle Valley Special Service. Sewer system. Data collected from 9/30/2002 – 11/30/2002.
1. Waste load allocations (WLA) are discussed in Table 6-1
2. Non-point source load = total existing load – point source load
3. Total existing load calculated based on available flow and water chemistry data over 11-year period (1990 – 2001)
4. Loading capacity = average annual flow for period of 1/1990-12/2001 x 1,200 mg/L x conversion factor
5. Margin of safety = 5% of loading capacity
6. Load reduction = total existing load – (loading capacity - margin of safety)
7. Point source is listed from WLA. Non-point= loading capacity- WLA- margin of safety

Table 6-6 Summary of Average Annual TDS Load and TMDL Load Allocation for the Rock Canyon Creek Watershed from Confluence with Cottonwood Creek to Headwaters (based on EWCD-09- Lower Rock Canyon Creek)

Source	TDS Load (tons/year)	WLA[1] (tons/year)
Point Source		
*None**		
Total Point Source Load	0	
Non-Point Source Load[2]	31,905	
Total Existing Load[3]	31,905	
Loading Capacity[4]	11,500	
Margin of Safety[5]	575	
Load Reduction Required to Meet Loading Capacity[6]	20,980	

Source	TMDL TDS Load Allocation[7] (tons/year)	% of Reduction in Existing Load to Achieve Allocation
Point Source	0	0%
Non-Point Source	10,925	66%
Margin of Safety	575	Not Applicable

Notes: * While there is no existing UPDES permit, the Hunter Power Plant (PacifiCorp) operations results in discharge to Rock Creek, permitting is underway

1. Waste load allocations (WLA) are discussed in Table 6-1
2. Non-point source load = total existing load – point source load
3. Total existing load calculated based on available flow and water chemistry data over 11-year period (1990 – 2001)
4. Loading capacity = average annual flow for period of 1/1990-12/2001 x 1,200 mg/L x conversion factor
5. Margin of safety = 5% of loading capacity
6. Load reduction = total existing load – (loading capacity - margin of safety)
7. Point source is listed from WLA. Non-point= loading capacity- WLA- margin of safety

Table 6-7 Summary of Average Annual TDS Load and TMDL Load Allocation for the Ferron Creek Watershed from Confluence with the San Rafael River to Headwaters (based on EWCD-11- Lower Ferron Creek)

Source	TDS Load (tons/year)	WLA[1] (tons/year)
Point Source		
NPDES UT0020052[a]	*95*	*986*
Total Point Source Load	95	986
Non-Point Source Load[2]	44,788	
Total Existing Load[3]	44,883	
Loading Capacity[4]	21,558	
Margin of Safety[5]	1,078	
Load Reduction Required to Meet Loading Capacity[6]	24,403	

Source	TMDL TDS Load Allocation[7] (tons/year)	% of Reduction in Existing Load to Achieve Allocation
Point Source	986	0%
Non-Point Source	19,494	57%
Margin of Safety	1,078	Not Applicable

Notes: a. Ferron Lagoon

1. Waste load allocations (WLA) are discussed in Table 6-1
2. Non-point source load = total existing load – point source load
3. Total existing load calculated based on available flow and water chemistry data over 11-year period (1990 – 2001)
4. Loading capacity = average annual flow for period of 1/1990-12/2001 x 1,200 mg/L x conversion factor
5. Margin of safety = 5% of loading capacity
6. Load reduction = total existing load – (loading capacity - margin of safety)
7. Point source is listed from WLA. Non-point= loading capacity- WLA- margin of safety

Table 6-8 Summary of Average Annual TDS Load and TMDL Load Allocation for the Lower San Rafael River Watershed from Confluence with the Green Ricer to Confluence with Huntington Creek (based on UTDEQ STORET 493029- San Rafael River at US 24 Crossing)

Source	**TDS Load (tons/year)**	**WLA[1] (tons/year)**
Point Source		
NPDES UTG040006[a]	*35*	*670*
NPDES UT0021296[b]	*0.001*	*730*
NPDES UTG040003[c]	*233*	*138*
NPDES UTG040022[d]	*0.0002*	
NPDES UT0025399[e]	*3*	*89*
NPDES UT0023663[f]	*730*	*1278*
NPDES UT0020052[g]	*95*	*986*
Total Point Source Load	1,096	3,891
Non-Point Source Load[2]	136,425	
Total Existing Load[3]	137,521	
Loading Capacity[4]	101,524	
Margin of Safety[5]	5,076	
Load Reduction Required to Meet Loading Capacity[6]	41,073	

Source	**TMDL TDS Load Allocation[7] (tons/year)**	**% of Reduction in Existing Load to Achieve Allocation**
Point Source	3,891	0%
Non-Point Source	92,557	33%
Margin of Safety	5,076	Not Applicable

Notes:
a. Co-Op Mining Company. Data collected from 5/30/1998-12/31/2002.
b. Castle Valley SSD-Huntington, Data collected from 10/31/2002-12/31/2002.
c. Pacificorp – Trail Mtn. Mine. Data collected from 1/31/1998 – 5/30/1998.
d. Interwest Mining CO-DES-BEE. Data collected from 10/31/2001 – 12/31/2001.
e. Talon Resources Inc. Data collected from 6/30/2002 – 12/31/2002.
f. Castle Valley Special Service. Sewer system. Data collected from 9/30/2002 – 11/30/2002.
g. Ferron Lagoons
1. Waste load allocations (WLA) are discussed in Table 6-1
2. Non-point source load = total existing load – point source load
3. Total existing load calculated based on available flow and water chemistry data over 11-year period (1990 – 2001)
4. Loading capacity = average annual flow for period of 1/1990-12/2001 x 1,200 mg/L x conversion factor
5. Margin of safety = 5% of loading capacity
6. Load reduction = total existing load – (loading capacity - margin of safety)
7. Point source is listed from WLA. Non-point= loading capacity- WLA- margin of safety

Table 6-9 Summary of Average Annual TDS Load and TMDL Load Allocation for the Upper Muddy Creek Watershed from Confluence with Ivie Creek to Highway 10 (based on EWCD-14- Lower Muddy Creek)

Source	TDS Load (tons/year)	WLA[1] (tons/year)
Point Source		
NPDES UT0022616[a]	*1,095*	*1,104*
NPDES UT0022918[b]	*2,500*	*10,044*
Total Point Source Load	3,595	11,148
Non-Point Source Load[2]	50,767	
Total Existing Load[3]	54,362	
Loading Capacity[4]	19,916	
Margin of Safety[5]	996	
Load Reduction Required to Meet Loading Capacity[6]	35,442	

Source	TMDL TDS Load Allocation[7] (tons/year)	% of Reduction in Existing Load to Achieve Allocation
Point Source	11,148	0%
Non-Point Source	7,772	86%
Margin of Safety	996	Not Applicable

Notes: a. Consolidation Coal CO-Underground Mine. Data collected from 9/30/1999 – 9/30/2002. Due to high flow from 9/30/1999 – 3/31/2000, only data from 4/30/2000 – 9/30/2002 was used for existing load calculations.

b. Canyon Fuel-SUFCO. Data collected from 5/2001-6/2003

1. Waste load allocations (WLA) are discussed in Table 6-1
2. Non-point source load = total existing load – point source load
3. Total existing load calculated based on available flow and water chemistry data over 11-year period (1990 – 2001)
4. Loading capacity = average annual flow for period of 1/1990-12/2001 x 1,200 mg/L x conversion factor
5. Margin of safety = 5% of loading capacity
6. Load reduction = total existing load – (loading capacity - margin of safety)
7. Point source is listed from WLA. Non-point= loading capacity- WLA- margin of safety

Table 6-10 Summary of Average Annual TDS Load and TMDL Load Allocation for the Lower Muddy Creek Watershed from Confluence with the Fremont River to Ivie Creek Confluence (based on UTDEQ STORET 495500- Muddy Creek at Old US 24 Crossing)

Source	TDS Load (tons/year)	WLA[1] (tons/year)
Point Source		
NPDES UT0022616[a]	*1,095*	*1,104*
NPDES UT0022918[b]	*2,500*	*10,044*
Total Point Source Load	3,595	11,148
Non-Point Source Load[2]	85,155	
Total Existing Load[3]	88,750	
Loading Capacity[4]	34,590	
Margin of Safety[5]	1,729	
Load Reduction Required to Meet Loading Capacity[6]	55,889	

Source	TMDL TDS Load Allocation[7] (tons/year)	% of Reduction in Existing Load to Achieve Allocation
Point Source	11,148	0%
Non-Point Source	21,713	76%
Margin of Safety	1,729	Not Applicable

Notes: a. Consolidation Coal CO-Underground Mine. Data collected from 9/30/1999 – 9/30/2002. Due to high flow from 9/30/1999 – 3/31/2000, only data from 4/30/2000 – 9/30/2002 was used for existing load calculations.
b. Canyon Fuel-SUFCO. Data collected from 5/2001-6/2003
1. Waste load allocations (WLA) are discussed in Table 6-1
2. Non-point source load = total existing load – point source load
3. Total existing load calculated based on available flow and water chemistry data over 11-year period (1990 – 2001)
4. Loading capacity = average annual flow for period of 1/1990-12/2001 x 1,200 mg/L x conversion factor
5. Margin of safety = 5% of loading capacity
6. Load reduction = total existing load – (loading capacity - margin of safety)
7. Point source is listed from WLA. Non-point= loading capacity- WLA- margin of safety

6.3.2 Summary of TDS Load Allocation

As discussed in Section 5-1, observed flow and TDS measurements were used to calculate the loading capacity for each watershed based on the existing criteria of 1,200 mg/L. The TDS load at each of the target sites within each watershed includes contributions from point and non-point sources, which also includes background sources. The point and non-point allocations for each location, along with a margin of safety, are summarized in Tables 6-2 through 6-10. As discussed in the Project Implementation Plan (Appendix A), attainment of the 1,200 mg/L is not feasible at all locations in the WCRW due to natural loading of TDS. For these locations, site specific criteria are recommended. The recommended values and the basis for theses values is provided in Appendix A.

7.0 PUBLIC PARTICIPATION

Two meetings were held in Price, UT with the Price-San Rafael Rivers Watershed Committee. The initial meeting was held in November 2002, with a subsequent meeting in May of 2003. Participants in the watershed committee, which was organized to provide local input into watershed issues in the West Colorado Watershed, include:

- San Rafael Soil Conservation District
- Price River Soil Conservation District
- Green River Soil Conservation District
- Muddy Creek Irrigation Company
- Ferron Canal and Reservoir Company
- Cottonwood Creek Irrigation Company
- Huntington/Cleveland Irrigation Company
- Price River Irrigation Company
- Carbon Canal Irrigation Company
- North Carbon Irrigation Company
- Emery County Commissioners
- Emery County Public Lands Council
- Emery County Water Conservancy District
- Price River Water Conservancy District
- Carbon County Commissioners
- Carbon County Planning and Zoning
- Utah Association of Conservation Districts (Zone 7)
- Utah Division of Water Quality
- Utah Division of Water Rights
- Utah Division of Wildlife Resources
- Bureau of Land Management
- US Forest Service
- Natural Resources Conservation Service
- Castleland RC&D Council
- US Fish and Wildlife Service
- Bureau of Reclamation
- Local cities and communities
- Other interested parties

The Price-San Rafael Rivers Watershed Committee is committed to the maintaining or improving the quality of water within its jurisdiction. There is a desire to work with all interests to keep the river systems as clean as possible, given the geologic constraints of the area, and still maintain economically viable communities.

It is important to have local input in order to affect water quality improvements and practices. Local irrigation companies and shareholders involved in agricultural production are already actively participating in the Colorado River Salinity Control Program to reduce salt (TDS) loading into the river systems through improved irrigation practices. This proven program will help reduce salt loading into the Price/San Rafael/Green/Colorado River systems. With local support, this and other water quality improvement practices can be implemented as may be recommended in the TMDL.

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APPENDIX A

PROJECT IMPLEMENTATION PLAN

APPENDIX B

WATER QUALITY DATA USED FOR LOAD CALCULATIONS

APPENDIX A

Project Implementation Plan

1.0 INTRODUCTION

The load reduction of TDS into WCRW streams is primarily associated with nonpoint sources. The implementation of best management practices (BMPs) aimed at controlling these sources is voluntary. The implementation plan was developed utilizing USEPA guidance for 319 projects while also considering the ongoing irrigation conversion program. At a minimum, the implementation plan will address the implementation options listed below. Additional management or treatment options may also be considered as the implementation is developed and refined during implementation of management activities.

1.1 TDS Sources

The majority of TDS loading in the WCRW streams is associated with nonpoint sources. Therefore, best management practices aimed at reducing TDS loading will focus on nonpoint sources. However, in order to limit TDS loadings from all sources, the inclusion of a concentration limit in future UPDES permits is also recommended. Permit limits will generally be based on the 1200 mg/L criteria, unless site specific considerations (i.e., site specific standards) support a different value. The derivation of each proposed permit limit is provided in Section 6.4.1 of the main report.

While there are several stream segments within the three subwatersheds- Price River, San Rafael River, and Muddy Creek- that are listed as impaired, the BMPs discussed are directed at decreasing load within the entire watershed and associated subwatersheds. Table A-1 lists each of the listed segments and the identified non-point sources of TDS load in each stream segment and the BMPs recommended for each type of source.

Table A-1. Non-point sources and recommended BMPs for each impaired stream reach

PRICE RIVER		
Non-supporting segment[1]	**Identified nonpoint source**	**Recommended BMPs**
Pinnacle Creek and Gordon Creek from confluence with Price River to headwaters	Irrigation return flows	Increase irrigation efficiency through the use of sprinkler type irrigation systems Improved surface irrigation techniques such as automated water control valves, water measuring devices, gated pipe, borders, water control structures, and tailwater recovery systems
	Canal seepage	Line canals with concrete
	Stockwater pond seepage	Install membrane liners
	Surface runoff	Plant vegetation buffer strips
	Streambank erosion	Construct fences and in-stream livestock watering stations to prevent streambank damage Stabilize streambanks with log abutments, cribs, rock diversion structures Restore/revegetate failing streambank areas
	Forest	Minimize access roads and stream crossings, install culverts, revegetate slopes
Price River and tributaries from Coal Creek confluence to Carbon Canal diversion	Irrigation return flows	Increase irrigation efficiency through the use of sprinkler type irrigation systems Improved surface irrigation techniques such as automated water control valves, water measuring devices, gated pipe, borders, water control structures, and tailwater recovery systems
	Canal seepage	Line canals with concrete
	Stockwater pond seepage	Install membrane liners
	Surface runoff	Plant vegetation buffer strips
	Streambank erosion	Construct fences and in-stream livestock watering stations to prevent streambank damage Stabilize streambanks with log abutments, cribs, rock diversion structures Restore/revegetate failing streambank areas

Table A-1. Non-point sources and recommended BMPs for each impaired stream (continued)

Non-supporting segment[1]	Identified non-point source	Recommended BMP's
PRICE RIVER (continued)		
Price River and tributaries from confluence with Green River to Soldier Creek confluence	Surface runoff	Plant vegetation buffer strips
	Livestock grazing	Move cattle out of pastures before overgrazing
	Recreational activities	Fence around sensitive areas, revegetate bare areas, close trails /roads that are eroded, implement education programs that focus on responsible use
	Streambank erosion	Construct fences and in-stream livestock watering stations to prevent streambank damage Stabilize streambanks with log abut-ments, cribs, rock diversion structures Restore/revegetate failing streambanks
	Urban runoff	Install vegetation filter strips along roadsides, construct detention ponds
SAN RAFAEL RIVER		
Cottonwood Creek from the confluence with Huntington Creek to Highway 57	Irrigation return flows	Increase irrigation efficiency through the use of sprinkler irrigation systems Improved surface irrigation techniques such as automated water control valves, water measuring devices, gated pipe, borders, water control structures, and tailwater recovery systems
	Canal seepage	Line canals with concrete
	Stockwater pond seepage	Install membrane liners
	Surface runoff	Plant vegetation buffer strips
	Streambank erosion	Construct fences and in-stream livestock watering stations to prevent streambank damage Stabilize streambanks with log abutments, cribs, rock diversion structures Restore/revegetate failing streambanks
	Urban runoff	Install vegetation filter strips along roadsides, construct detention ponds
	Forest	Minimize access roads and stream crossings, install culverts, revegetate slopes

Table A-1. Non-point sources and recommended BMPs for each impaired stream (continued)

SAN RAFAEL RIVER (continued)		
Non-supporting segment[1]	**Identified non-point source**	**Recommended BMP's**
Huntington Creek and tributaries from confluence with Cottonwood Creek upstream to USFS boundary	Irrigation return flows	Increase irrigation efficiency through the use of sprinkler type irrigation systems Improved surface irrigation techniques such as automated water control valves, water measuring devices, gated pipe, borders, water control structures, and tailwater recovery systems
	Canal seepage	Line canals with concrete
	Stockwater pond seepage	Install membrane liners
	Surface runoff	Plant vegetation buffer strips
	Streambank erosion	Construct fences and in-stream livestock watering stations to prevent streambank damage Stabilize streambanks with log abutments, cribs, rock diversion structures Restore/revegetate failing streambank areas
	Urban runoff	Install vegetation filter strips along roadsides, construct detention ponds
	Forest	Minimize access roads and stream crossings, install culverts, revegetate slopes
San Rafael River from Buckhorn Crossing to the confluence with Huntington Creek and Cottonwood Creek	Surface runoff	Plant vegetation buffer strips, monitor cattle grazing pressure, limit recreation near streams
	Streambank erosion	Construct fences and in-stream livestock watering stations to prevent streambank damage Stabilize streambanks with log abutments, cribs, rock diversion structures Restore/revegetate failing streambank areas
San Rafael River from the confluence with the Green River to Buckhorn Crossing	Surface runoff	Plant vegetation buffer strips
	Livestock grazing	Move cattle out of pastures before overgrazing
	Recreational activities	Fence around sensitive areas, revegetate bare areas, close trails /roads that are eroded, implement education programs that focus on responsible use
	Streambank erosion	Construct fences and in-stream livestock watering stations to prevent streambank damage Stabilize streambanks with log abutments, cribs, rock diversion structures Restore/revegetate failing streambanks

Table A-1. Non-point sources and recommended BMPs for each impaired stream (continued)

MUDDY CREEK WATERSHED		
Non-supporting segment[1]	**Identified non-point source**	**Recommended BMP's**
Muddy Creek and tributaries from Quitchipah Creek confluence to the Utah Highway 10 bridge	Irrigation return flows	Increase irrigation efficiency through the use of sprinkler type irrigation systems Improved surface irrigation techniques such as automated water control valves, water measuring devices, gated pipe, borders, water control structures, and tailwater recovery systems
	Canal seepage	Line canals with concrete
	Stockwater pond seepage	Install membrane liners
	Surface runoff	Plant vegetation buffer strips
	Streambank erosion	Construct fences and in-stream livestock watering stations to prevent streambank damage Stabilize streambanks with log abutments, cribs, rock diversion structures Restore/revegetate failing streambank areas
	Urban runoff	Install vegetation filter strips along roadsides, construct detention ponds
	Forest	Minimize access roads and stream crossings, install culverts, revegetate slopes
Quitchupah Creek from the confluence with Ivie Creek to the Utah Highway 10 bridge	Irrigation return flows	Increase irrigation efficiency through the use of sprinkler type irrigation systems Improved surface irrigation techniques such as automated water control valves, water measuring devices, gated pipe, borders, water control structures, and tailwater recovery systems
	Canal seepage	Line canals with concrete
	Stockwater pond seepage	Install membrane liners
	Surface runoff	Plant vegetation buffer strips
	Streambank erosion	Construct fences and in-stream livestock watering stations to prevent streambank damage Stabilize streambanks with log abutments, cribs, rock diversion structures Restore/revegetate failing streambank areas
	Urban runoff	Install vegetation filter strips along roadsides, construct detention ponds
	Forest	Minimize access roads and stream crossings, install culverts, revegetate slopes

Table A-1. Non-point sources and recommended BMPs for each impaired stream (continued)

MUDDY CREEK WATERSHED (continued)		
Non-supporting segment[1]	**Identified non-point source**	**Recommended BMP's**
Ivie Creek and tributaries from the confluence with Muddy Creek to Utah Highway 10	Irrigation return flows	Increase irrigation efficiency through the use of sprinkler type irrigation systems Improved surface irrigation techniques such as automated water control valves, water measuring devices, gated pipe, borders, water control structures, and tailwater recovery systems
	Canal seepage	Line canals with concrete
	Stockwater pond seepage	Install membrane liners
	Surface runoff	Plant vegetation buffer strips
	Streambank erosion	Construct fences and in-stream livestock watering stations to prevent streambank damage Stabilize streambanks with log abutments, cribs, rock diversion structures Restore/revegetate failing streambank areas
	Urban runoff	Install vegetation filter strips along roadsides, construct detention ponds
	Forest	Minimize access roads and stream crossings, install culverts, revegetate slopes
Muddy Creek from the confluence with Fremont River to Quitchupah Creek confluence	Surface runoff	Plant vegetation buffer strips
	Streambank erosion	Construct fences and in-stream livestock watering stations to prevent streambank damage Stabilize streambanks with log abutments, cribs, rock diversion structures Restore/revegetate failing streambank areas
	Forest	Minimize access roads and stream crossings, install culverts, revegetate slopes

[1] Listed segments are consistent with the draft Utah 2004 303 (d) list of waters. The target sites discussed in the main report cover these segments (though not at each listed segment). Target sites were selected based on the availability of sufficient data to allow for loading calculations.

Estimated TDS loading from different non-point sources are listed for each of the target sites in the Price River, San Rafael River, and Muddy Creek watersheds in Tables A-2 through A-10. These locations are shown on Map 2 in the main report. Loadings for each target site were estimated using percentage of total area or by percentage of stream length for each target site. While we believe these estimates are a fair representative of actual conditions in the watershed, they are only estimates. Caution is advised in interpreting these data. The methods used to derive the allocation are discussed in Appendix Section 2.0.

Table A-2. Price River watershed (UTDEQ STORET Station 493239- Price River near Wellington at US 6 Crossing) non-point TDS sources, loadings, and reductions

Source	**Loading (tons/year)**	**Reduction (tons/year)**
Irrigation return flows	65,470	55,980
Canal seepage	4,677	3,692
Winter water replacement	18,706	14,685
Surface erosion	3,555	1,997
Streambank erosion	112	84
Urban areas	90	28
Forest	204	64
Totals	**92,814**	**76,530**
Ambient loading	**2,030**	**0**
TOTAL LOADING	**94,844**	**18,314 (post BMP)**

Table A-3. Price River watershed (between UTDEQ STORET Station 493239 and UTDEQ STORET Station 493165- Price River near Woodside at US 6 Crossing) non-point TDS sources, loadings, and reductions

Source	**Loading (tons/year)**	**Reduction (tons/year)**
Irrigation return flows	16,368	13,995
Canal seepage	1,169	923
Winter water replacement	4,676	3,671
Surface erosion	6,601	3,709
Streambank erosion	167	125
Urban areas	5	1
Forest	11	3
Totals	**28,997**	**22,427**
Ambient loading	**508**	**0**
TOTAL LOADING	**29,505**	**7,078 (post BMP)**

Table A-4. San Rafael watershed (EWCD 3- lower Huntington Creek) non-point TDS sources, loadings, and reductions

Source	Loading (tons/year)	Reduction (tons/year)
Irrigation return flows	27,809	17,586
Canal seepage	1,994	1,163
Winter water replacement	7,974	5,085
Surface erosion	3,218	1,869
Streambank erosion	51	38
Urban areas	13	4
Forest	80	24
Totals	**41,139**	**25,769**
Ambient loading	**2,214**	**0**
TOTAL LOADING	**43,353**	**17,584 (post BMP)**

Table A-5. San Rafael watershed (EWCD 9- lower Rock Canyon Creek) non-point TDS sources, loadings, and reductions

Source	Loading (tons/year)	Reduction (tons/year)
Irrigation return flows	11,961	7,537
Canal seepage	854	498
Winter water replacement	3,417	2,179
Surface erosion	2,146	1,246
Streambank erosion	25	19
Urban areas	4	1
Forest	34	7
Totals	**18,441**	**11,487**
Ambient loading	**949**	**0**
TOTAL LOADING	**19,390**	**7,903 (post BMP)**

Table A-6. San Rafael watershed (EWCD 7- lower Cottonwood Creek) non-point TDS sources, loadings, and reductions

Source	Loading (tons/year)	Reduction (tons/year)
Irrigation return flows	23,922	15,074
Canal seepage	1,709	997
Winter water replacement	3,417	2,179
Surface erosion	3,218	1,869
Streambank erosion	51	38
Urban areas	12	4
Forest	69	21
Totals	**32,398**	**20,182**
Ambient loading	**1,898**	**0**
TOTAL LOADING	**34,296**	**14,114 (post BMP)**

Table A-7. San Rafael watershed (EWCD 11- lower Ferron Creek) non-point TDS sources, loadings, and reductions

Source	Loading (tons/year)	Reduction (tons/year)
Irrigation return flows	15,948	10,049
Canal seepage	1,139	664
Winter water replacement	4,557	2,906
Surface erosion	3,218	1,869
Streambank erosion	51	38
Urban areas	8	2
Forest	46	14
Totals	**24,967**	**15,542**
Ambient loading	**1,265**	**0**
TOTAL LOADING	**26,232**	**10,690 (post BMP)**

Table A-8. San Rafael watershed (river segment from confluence with Huntington Creek, Cottonwood Creek and Ferron Creek to UTDEQ STORET 493029 - San Rafael River at US 24 Crossing) non-point TDS sources, loadings, and reductions

Source	Loading (tons/year)	Reduction (tons/year)
Irrigation return flows	0	0
Canal seepage	0	0
Winter water replacement	3,417	2,187
Surface erosion	9,756	5,607
Streambank erosion	76	57
Urban areas	0	0
Forest	0	0
Totals	**13,148**	**7,851**
Ambient loading	**0**	**0**
TOTAL LOADING	**13,249**	**5,398 (post BMP)**

Table A-9. Muddy Creek watershed (headwaters to EWCD-14) nonpoint TDS sources, loadings, and reductions

Source	Loading (tons/year)	Reduction (tons/year)
Irrigation return flows	25,600	18,950
23,663Canal seepage	360	247
Winter water replacement	1,440	1,030
Surface erosion	5,751	3,344
Streambank erosion	60	45
Urban areas	6	2
Forest	148	45
Totals	**33,365**	**23,663**
Ambient loading	**30,970**	**0**
TOTAL LOADING	**64,335**	**40,672 (post BMP)**

Table A-10. Muddy Creek watershed (stream segment from EWCD-14 to UTDEQ STORET 495500) nonpoint TDS sources, loadings, and reductions

Source	Loading (tons/year)	Reduction (tons/year)
Irrigation return flows	6,410	4,737
Canal seepage	90	62
Winter water replacement	360	256
Surface erosion	8,626	5,015
Streambank erosion	91	68
Urban areas	0	0
Forest	0	0
Totals	**15,577**	**10,138**
Ambient loading	**7,743**	**0**
TOTAL LOADING	**23,320**	**13,182 (post BMP)**

As indicated in Tables A-2 through A-8, the annual ambient TDS loadings to the Price and San Rafael River watersheds is approximately 2 to 5% of the existing annual load. This loading is attributed to natural 'background' loading that results primarily from groundwater discharge to the system. It is important to note that some degree of surface erosion and stream bank erosion is also natural to the system, and should be considered as background loading as well. The allocation of non-point source TDS loading in the Muddy Creek watershed is unique from the Price and San Rafael. In Muddy Creek, between 45 and 93% of the annual load is from ambient loading (Tables A-9 and A-10). This finding is in agreement with other studies in the Muddy Creek watershed which have reported that much of the annual load results from inputs from salt washes that occur within the watershed (BOR 1987, Miller 2003). Additionally, the Muddy Creek portion of the WCRW has less irrigated acreage than does the Price and San Rafael watersheds, which results in less return flow loadings of TDS.

1.2 Potential Best Management Practices (BMPs)

As listed in Tables A-2 through A-10, the majority of nonpoint source TDS loads in the WCRW watersheds, especially in the upper Price and to a lesser extent in the upper portions of the San Rafael watersheds, are associated with irrigation practices. Other nonpoint TDS sources include animal grazing, forestry related activities, urban runoff, erosion, stock pond seepage, and recreational activities. BMP's have been identified for each of these TDS sources.

The implementation of BMPs will aid in the preservation of current water uses by reducing the TDS loadings throughout the watershed. The following list of BMP options provides some potential management activities that can reduce TDS loadings to streams in the Study Area:

- Increase irrigation efficiency thereby reducing deep percolation of surface water
- Control canal and ditch seepage by limiting infiltration losses

- Install membrane liners on stockwater ponds to prevent seepage
- Create vegetated buffer strips along streams and ditches to reduce erosion
- Revegetate stream banks with soil holding species, use rock barbs to divert flow from banks, and re-slope steep streambanks to allow for vegetation establishment
- Maintain plant cover with proper grazing strategies
- Improve riparian condition by excluding grazing and through planting wetland species
- Limit recreational vehicle usage to non-sensitive areas away from streams
- Revegetate coal mine spoil to prevent erosion and deep percolation
- Plug abandoned wells to prevent saline discharge into streams
- Construct stormwater retention ponds in urban areas

2.0 RECOMMENDATIONS

The BMPs recommended for application within the WCRW are described below.

2.1 Irrigation

Mitigation of irrigation associated TDS would be accomplished by installing gravity pressure sprinkler systems, pump pressurized sprinkler systems, or through surface irrigation improvements. Sprinkler systems improvements would include mains and laterals, pipelines with risers, sprinkler hardware, pumps and motors, and water measuring devices. Surface irrigation improvements would include water measuring devices, water control structures, land leveling, pipelines, gated pipe, borders, automated water control valves, and tail water recovery systems (BOR and SCS 1993). Soil moisture meters should be used by all irrigators to ensure that excessive amounts of water are not applied to fields. Additionally, technical assistance provided to irrigation companies and landowners alike would result in improved management of water delivery and application.

Under the RP (Resource Protection) plan, there are approximately 17,000 acres under consideration for irrigation improvements for the Price River watershed and 19,000 acres under consideration for irrigation improvements in the San Rafael River watershed. Current furrow irrigation practices in the WCRW have a water use efficiency of 35% or less (BOR and SCS 1993). The projected on-farm irrigation efficiency for the RP plan using a combination of improved surface irrigation, pressure sprinkler irrigation, and gravity sprinkler systems is 60%. The RP plan is projected to decrease the salt load in the Price River watershed by 69,975 tons per year and by 50,245 tons per year in the San Rafael River watershed (BOR and SCS 1993). Application of the same irrigation improvements to the 5,500 irrigated acres in the Muddy Creek watershed could potentially reduce the annual salt load in the WCRW by an additional 23,687 tons, or by 143,907 tons per year in the entire Study Area. Uses of newer center pivot irrigation systems, which have an average efficiency of 77.5% (Texas A&M 2001), could reduce the annual salt load in the WCRW by 169,080 tons per year. Center pivot irrigation systems that employ the use of 16 inch drop heads would increase efficiency to 85-90% (Texas A&M 2001), resulting in a potential reduction of 183,469 tons of salt entering the WCRW streams. The efficiency of furrow irrigation could be increased to 75% (NCSU 2003) with the installation of surge flow irrigation valves. If this technology was employed on all of the Study Area’s irrigated acreage, the annual salt load reduction in the WCRW watersheds could total 179,884 tons.

2.2 Open Lateral Replacement

Seepage from open laterals that supply water for irrigation purposes could be reduced by replacing open laterals and canals with pipe. Replacing 100% of the 69 miles of open laterals and canals in the Price River watershed and 87 miles of open laterals in the San Rafael watershed could potentially reduce the salt load by nearly 8,000 tons per year (BOR and SCS 1993). Replacing all 9 miles of open laterals and canals in the Muddy Creek watershed could potentially reduce the salt load into the WCRW streams by an additional 460 tons per year.

2.3 Winter Water Replacement

Water delivery canals for livestock and municipal use that are operated in the winter cause additional TDS loading due to seepage. Winter water could be supplied from other sources and the canals could be dewatered during the winter months. Additionally, stock ponds could be lined with impervious materials to prevent seepage. According to BOR and SCS (1993), dewatering of the Price River and San Rafael area canal systems in winter and lining stock ponds could result in a load reduction of 18,356 and 14,529 tons of salt per year, respectively. While the number of stock ponds in the Muddy Creek watershed is unknown, the application of similar BMPs in this watershed would be expected to produce a proportional load reduction on a per pond basis.

2.4 Surface Erosion

The main factor controlling sediment production due to surface erosion is the percentage of grass cover (Dadkuh and Gifford 1980). The presence of grass aids in binding soil particles together as well as slowing overland flow and allowing sediment to settle out of suspension. Grass cover percentages of 50% or more minimize the amount of sediment production on rangelands. While rangelands in the WCRW would benefit from improved range condition through seeding efforts, the cost would be prohibitively high for the amount of salt removed. The most effective means for improving grass cover on rangelands is through proper grazing management. Livestock producers should be educated about range management practices that maintain or enhance vegetation cover in the Study Area. Through the employment of strategies such as controlling overall livestock density and distribution, and season of use, livestock can be used successfully for vegetation management.

Roads in the lower portion Study Area can significantly increase the loading into nearby streams. The lack of vegetative cover on road surfaces and ditch slopes can allow sediment to flow unimpeded into streams and other water bodies. As mentioned previously, grass cover can significantly reduce the amount of sediment production. Vegetation buffers strips that are 50 feet wide along both sides of roads could be expected to reduce sediment production by at least 50%.

Recreational activities result in a reduction in vegetative ground cover and increased soil compaction which can eventually lead to higher rates of runoff and erosion. The impacts of recreation on stream loading can be reduced by maintaining sufficient ground cover in areas susceptible to erosion, such as campsites, trails, and vehicle usage areas. BMPs would include fencing to eliminate usage in sensitive areas, revegetation of bare areas, and select road/trail closures. Education programs that focus on responsible use of resources are perhaps the most effective means for reducing the impact from recreational activities.

Vegetation filter strips along streams can measurably reduce sediment inflow to the streams. The recommended width for buffer strips along streams and other water bodies is 50 feet. If both sides of a stream are buffered, the resulting filter strips would occupy approximately 12 acres over the course of one mile of stream length. It is estimated that 50 foot wide buffer strips on both sides of a stream could reduce sedimentation from 56 to 95% (Leeds et al. 2003, Parsons et al. 1994, Snyder et al. 1998). The current estimates of surface erosion induced TDS loading are 10,156 tons per year in the Price River watershed, 21,455 tons per year in the San Rafael River watershed, and 14,377 tons per year in the Muddy Creek watershed. After the implementation of filter strips to control erosion and assuming a 60% sediment reduction estimate, a potential TDS reduction of 6,094, 12,873, and 8,626 tons per year from barren land, roads, rangeland, and agricultural land in the Price River, San Rafael River, and Muddy Creek watersheds, respectively, may be realized.

2.5 Streambank Erosion

Based on published literature (Rosgen 2000, Bouquetriver 2003), it is estimated that unstable stream banks in the WCRW add approximately 684 tons of salt per year to streams. Of this total, the Price River watershed contributes 279 tons, the San Rafael River watershed contributes 254 tons, and the Muddy Creek watershed contributes 151 tons per year. Areas where livestock and wildlife cross streams or where they frequently water can cause vegetation loss, and ultimately, bank failure. Salt loading due to erosion can be reduced by installing fencing to concentrate livestock in engineered in-stream watering stations. Fencing will keep livestock out of sensitive areas and allow for restoration of the site. Erosion can also be lessened by restoring/stabilizing stream banks with log abutments, cribs, rock diversion structures, and revegetation of streambank areas that are in imminent danger of failing, or have already failed. Restoration/revegetation efforts on streambank areas can reduce salt loading from unstable stream banks in the WCRW by 75%. It is estimated that approximately 5%, or 100 miles, of stream banks in the WCRW are contributing to the salt load through bank failure.

2.6 Urban Runoff

Urban areas increase the total amount of runoff because of the many impervious surfaces, such as roads, roofs, and parking lots. New development in urban areas can also potentially increase sediment yields due to disturbed soil conditions commonly found near construction sites. Urban runoff may contain salt-laden sediment and dissolved road salts that potentially add up to 138 tons of salt annually in the WCRW. Urban areas in the Price River watershed contribute 95 tons of salt annually, while urban areas in the San Rafael and Muddy Creek watersheds adds an additional annual load of 37 tons and 6 tons, respectively. Vegetation filter strips located along roadsides can help prevent erosion and thus salt laden soil from reaching streams in the Study Area. Detention ponds can control runoff rates and allow sediment to settle (USEPA 2003a, Law et al. 1998). An estimated 29 tons of salt can be removed each year from WCRW streams by the application of vegetative filter strips and detention ponds in urban areas in the Price River watershed. Applying these same BMPs to urban areas in the San Rafael and Muddy Creek watersheds can result in a load reduction of 11 tons and 2 tons annually, respectively.

2.7 Forest Runoff

Most forested areas have low sediment yields because soils are generally stable and vegetative cover is high. Erosion problems are usually associated with surface disturbance through logging, grazing, or recreational activities. Forests in the WCRW are not intensively used for logging, though grazing and recreational activities do occur. The main source of sediment in forests of the WCRW is vehicle use of forest access roads. The Muddy Creek watershed also contains steep canyons that increase loadings at certain times of the year. Sediment loss associated with forest roads can range from 6.8 tons per acre at a slope of 1%, to 32.3 tons per acre at a 6% slope (SFRA 2002). Even though forested areas are not underlain by Mancos shale formations, it is estimated that approximately 215 tons of salt from the Price River, 229 tons of salt from the San Rafael River, and 45 tons of salt from the Muddy Creek watersheds are added to the loading of WCRW streams due to forest roads. It is estimated that the existing salt load could be reduced by 30% through the adoption of forest road BMPs such as revegetation of cut and fill slopes, installing culverts, avoiding development of forest roads when possible, minimizing stream crossings, and other similar measures. This would equate to an annual salt load reduction of 67 tons in the Price River watershed, 66 tons in the San Rafael watershed, and 45 tons in the Muddy Creek watershed.

3.0 COSTS

Cost effectiveness is a primary criterion for BMP selection. Some of the BMPs described in Section 2 are relatively inexpensive to implement, while others are probably cost prohibitive. A summary of estimated costs for these BMPs is presented below. These costs, which are in 2003 dollars, are a general estimate only. Actual costs may vary depending on local economies, transportation costs, inflation, etc.

3.1 Irrigation Improvement

Irrigation improvement was originally presented by the BOR and SCS (1993) and included pressurized sprinkler systems, gravity sprinkler systems, and improved surface irrigation. The following irrigation improvement increment is essentially the same as that of the BOR, but with improved irrigation efficiencies due to ongoing irrigation R&D and the resulting improved technologies.

A good portion of the agricultural land in the WCRW is well adapted to center pivot sprinkler or other wheel type irrigation practices, such as hand lines. The total initial cost of a new 80 acre center pivot irrigation system is approximately $947 per acre and the total annual operating costs, including labor, fuel and oil, repairs and maintenance, depreciation, and interest are approximately $58 per acre (Tyson and Curtis 1997). Total annual cost for the useful life of this system (20 years) is approximately $230 per irrigated acre and the cost of salt removed is $58 per ton (Table A-11). When full length drop-down tubes (low heads) are used with this system, the percent efficiency increases to an average of 87.5% (NMOSE 2001) and the cost of salt removed drops to $54 per ton (Table A-11).

Surge flow surface irrigation systems are a cost effective means of reducing irrigation return flows and thus salt loading. The total annual cost of a surge flow system is approximately $75 per acre, which includes all PVC piping, valves, and operating expenses (Texas A&M 2001). The cost for removing one ton of salt per year from WCRW streams with surge flow irrigation is approximately $20. Installation costs, and thus the costs of removing salts, would be less on existing PVC irrigation piping.

3.2 Canal Seepage/Winter Water

In 1993 the BOR and SCS estimated that canals delivering water for livestock and municipal use during the winter months cause additional salt loading to WCRW streams due to seepage from canals and stock ponds. Dewatering WCRW canals in winter and by excavating stock ponds, lining stock ponds with PVC or clay liners, installing waterers, and fencing out livestock, would reduce the salt load by an estimated 32,880 tons per year. The BOR and SCS estimated that the cost for this project would be $499,400, or

$15 per ton of salt removed in 1989 dollars. Based on 2003 prices this project would cost approximately $23 per ton of salt removed from the system (Table A-11).

3.3 Surface Erosion Reduction

As previously stated, filter strips would reduce surface erosion and the resulting salt loading in the WCRW streams. Initial costs for the installation of filter strips would be confined to tillage and seeding operations. Tillage operations would consist of disking the area prior to seeding. Seeding operations would be performed with a rangeland drill. The total cost of tilling, seed, and seeding operations of filter strips would cost approximately $400 per acre, or $4800 per mile (USEPA 2003b). Assuming that approximately 10% of the streambank areas are in need of filter strips, the total mileage of streambank filter strips would be approximately 200 miles. The annual cost to remove salts from the WCRW streams due to surface erosion is approximately $32 per ton (Table A-11).

3.4 Streambank Restoration/Stabilization

Streambank restoration and stabilization would include activities such as grading damaged streambank areas, seeding/transplanting where vegetation is sparse or non-existent, and fencing to exclude livestock. The costs associated with streambank restoration/revegetation and fencing is estimated at approximately $5000 per mile, resulting in a cost of $974 per ton of salt removed (Purdue University 2003, USEPA 2003b) (Table A-11).

3.5 Forest Related Activities

Cost analysis was not performed for this salt loading source because of the relatively minor effects on salt loading into the WCRW streams. Additionally, the costs associated with BMPs for this source are highly variable and are likely not competitive with the other treatment options presented.

Table A-11. Salt loading sources, BMPs, costs, efficiencies, and salt removed per year in the WCRW

BMP Assessment Table				
Source	**Alternative BMP**	**Annual Cost /ton (2003)**	**Efficiency**	**Tons of salt removed/year**
Current on-farm systems (BOR and SCS 1993)	Pressure and gravity irrigation, improved surface irrigation (SCS on-farm improvements)	$58	50 - 65%	143,907
Current off-farm delivery systems (BOR and SCS 1993)	Replacement of open laterals (RP)	$181	100%	8,246
Furrow irrigation	Center Pivot Irrigation gravity/pump	$58	75-80%	169,080
Furrow irrigation	Center Pivot Irrigation with low heads (16")	$54	85-90%	183,469
Furrow irrigation	Furrow Irrigation with Surge Valves	$20	80-90%	179,884
Unlined stockwater ponds, canal seepage	Excavation, PVC liner and waterers	$22	100%	N/A
Denuded land	Vegetation Buffer Strips	$32	60%	27,409
Damaged streambanks	Stabilization with grading, seeding, transplanting	$974	75%	513

4.0 MONITORING PROGRAM

In developing this TMDL, it has been noted that there is an inadequate amount of data to completely characterize all of the components of the TMDL. Given these data limitations, it is suggested that further data be collected and the TMDL be refined, as appropriate, based on the results of additional analysis (a more complete data set would include monthly data over the entire year to better evaluate both high-flow and low-flow periods). Nonetheless, the results of this TMDL can provide a basis for future data collection and implementation of some of the actions and management measures required to implement the allocations provided in this report. As new data becomes available through monitoring efforts, elements of the TMDL may be changed to reflect this new information.

Several implementation components directed towards reduction of TDS loading can be established while new data is being developed. It is noted, however, that uncertainties exist regarding the potential effectiveness of some of these recommended practices, and that implementation of the recommended practices may be constrained by other factors. Issues such as water rights, in-stream flows, and restrictions on land application will also need to be considered during the development of specific control programs. Alternative options to treat discharge waters may also be required if TMDL endpoints cannot be achieved through the current implementation strategy. These options will be evaluated at the appropriate time, after implementation of the current recommendations and collection of additional data.

Salt loading in the Muddy Creek watershed differs from that of the Price River and San Rafael river watersheds due to the abundance of springs and salt washes in the area. Although implementation of BMPs may reduce salt loading in the Price River and San Rafael River watersheds to acceptable levels, BMP implementation in the Muddy Creek watershed will not reduce salt loading to the extent necessary to meet current water quality criteria. Natural springs and salt washes in the Muddy Creek watershed are a significant source of salts, and BMPs will have little effect, if any, on reducing the salt load from these sources.

4.1 Future Water Quality Monitoring

A water-monitoring program needs to be conducted to further validate or define loading sources, and to monitor stream responses to implementation actions. Continued water quality monitoring is essential for evaluating the effects of BMPs and the progress of meeting water quality standards. The program should be designed to measure stream flows conditions over an entire year, encompassing both the spring-runoff period and the low flow period. At a minimum, TDS and flow should be monitored at the target points.

4.2 Summary

As shown in Table A-5, the cost and effectiveness of the listed BMPs is quite variable. BMP selection criteria should include not only cost and effectiveness of the BMP, but also the ease of putting the particular BMP in place. Once a particular BMP has been shown to reduce salt loading, other BMPs will likely be adopted.

In the final analysis, no matter which BMPs are put into place in the WCRW, salt loading will be reduced. However, it must be noted that while BMPs will decrease the salt *load* into WCRW streams, the concentration of TDS in certain stream segments may still not meet the numeric criteria for these waters. Because the ability to meet the water quality criteria is not solely dependent on the TDS load, a monitoring program is critical to understanding the ultimate impact of BMP implementation on TDS concentrations in the WCRW.

5.0 SITE-SPECIFIC CRITERIA

As discussed in Appendix Section 4.0, salt loading in the Muddy Creek watershed differs from that of the Price River and San Rafael river watersheds due to the abundance of springs and salt washes in the area. While implementation of BMPs will reduce salt loading in the Price River and San Rafael River watersheds, BMP implementation in the Muddy Creek watershed will not reduce salt loading to the extent necessary to meet current water quality criteria. While implementation of the BMPs, will reduce salt loadings in each of the watersheds, it *may not* reduce the concentration of TDS in the watersheds, due to potential concurrent reductions in flow. While the stream reaches are identified as impaired due to exceedance of numeric criteria, the purpose of the TMDL process is to reduce load and to lower TDS concentrations in each reach.

Due to the uncertainty in what are achievable TDS concentrations in each watershed, it is recommended that the selection of site-specific TDS criteria be established at this time. The site-specific criteria should be revisited after implementation of BMPs and subsequent monitoring of the resulting changes in the TDS concentrations in each of the stream reaches. In order to establish site-specific criteria, the dataset from 1990 to 2001 was reviewed for the lower stations in each watershed, and the 90th percentile TDS concentration determined. This 90th percentile was selected as the criteria so that the watersheds could be listed as fully supporting during the BMP implementation period. This designation also recognizes that, with only minor exceptions, water used for irrigation in the WCRW is sourced from the upper portion of the watersheds, where TDS levels are typically less then 500 mg/L and therefore meet the agricultural criteria of 1200 mg/L. The calculated 90th percentile values for each of the target sites evaluated in the main report are listed in Table A-12. While the Muddy Creek value of 5800 mg/L seems quite high, the BOR (1987) states that surface flows from salt washes in the watershed "exhibit average flow-weighted concentrations of about 5,600 mg/L TDS" and that concentrations of TDS in groundwater that discharges to Muddy Creek average about 6,700 mg/L TDS. The calculated value of 5800 mg/L falls within these reported concentrations.

While the 90th percentile TDS value may be an appropriate site-specific criteria for some of the target sites, it is anticipated that due to significant reductions in TDS loadings through BMP implementation, the criteria of 1200 mg/L may be meet at the target sites below areas of significant man-induced TDS loadings. In particular, the Wellington Bridge target site in the Price watershed, where agricultural BMPs will reduce salt loads, but where attainment of the current 1200 mg/L criteria is not feasible. Table A-12 lists the 90th percentile TDS values at each target site and the recommended site-specific TDS criteria for each listed stream reach based on this analysis.

Table A-12. 90th Percentile Values of TDS at each Target Site and Site Specific Criteria

Target Site	90th Percentile TDS (mg/L)	Listed Stream Reaches Above or Near Target Site	Recommended Criteria (mg/L)
Price River			
493239- Above WWTP at Wellington Bridge	2,800	Pinnacle[1] and Gordon Creeks and their tributaries from confluence with Price River to headwaters Price River and tributaries from Coal Creek to Carbon Canal diversion	1,200[2]
493165- Lower Price River near Woodside	3,200	Price River and tributaries from confluence with Green River to near Woodside Price River and tributaries from near Woodside to Soldier Creek confluence	3,200
San Rafael River			
EWCD-03- Lower Huntington Creek	4,800	Huntington Creek tributaries from the confluence with Cottonwood Creek to Utah highway 10 Huntington Creek and tributaries from Highway 10 crossing to USFS boundary	3,500[3]
EWCD-07- Lower Cottonwood Creek	3,500	Cottonwood Creek from the confluence with Huntington Creek to Highway 57	3,500[3]
EWCD-09- Lower Rock Canyon Creek	5,400	Rock Canyon Creek from confluence with Cottonwood Creek to headwaters[1]	3,500[3]
EWCD-11- Lower Ferron Creek	4,000	Ferron Creek from confluence with San Rafael River to Highway 10[1]	3,500[3]
493029- San Rafael at US 24 Crossing	4,100	San Rafael River from Buckhorn Crossing to the confluence with Huntington Creek and Cottonwood Creek San Rafael River from the confluence with the Green River to Buckhorn Crossing	4,100
Muddy Creek			
EWCD-14- Lower Muddy Creek	2,600	Muddy Creek and its tributaries from Quitchupah Creek confluence to the Highway 10 Quitchupah Creek from confluence with Ivie Creek to Highway 10 Ivie Creek and its tributaries from the confluence with Muddy Creek to Highway 10	2,600
495500- Muddy Creek at Old US24 Crossing	5,800	Muddy Creek from the confluence with Fremont River to Quitchupah Creek confluence	5,800

1. Though not listed in the draft Utah 2004 303(d) list, data indicates that these reaches are impaired by TDS
2. The existing criteria of 1,200 mg/L may be achievable after implementation of BMPs
3. Based on the analysis of the most current data, a value of 3,500 mg/L may be attainable.

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